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RAYMOND OLNEY
Editor and Business Manager

EDITORIAL

Follow-Up on Corn Conditioning

QUICK action was taken in two ways to increase the effectiveness of the Conference on Conditioning the 1947 Corn Crop held at Chicago in July.

First, the office of the Secretary of Agriculture in Washington informed the material manufacturers concerned as to the urgency of the situation and the need of their making preferential allotments of needed materials and component parts to the manufacturers of grain-drying equipment, to expedite its production in the two to three months which remained before the harvest season; also, to farm supply dealers for the parts farmers can assemble themselves.

Second, the U. S. Department of Agriculture quickly assembled at Purdue University a group of its agricultural engineers familiar with grain-drying problems to give the drier manufacturers, farmers, and grain handlers all possible help.

This help developed in three directions. Functional specifications for driers and their component parts were related to a series of sizes and capacities desired in completed units.

All new information on driers was quickly made available to everyone concerned with the production of one or more driers, to the end that a maximum number of workable units might be available to start work as soon as the corn harvest begins.

And plans have been made to get maximum production out of the available driers by farm ownership, rental, custom work, scheduling, movement of units from farm to farm, community cooperation, and assistance from the various state and federal farm service agencies.

It all adds up to a strong object lesson in timely, practical action to alleviate the shortage and accompanying inflationary prices of important public necessities.

Agricultural engineers can take justifiable pride in their contribution to this program.

Re-Elevation in Research

THE current series of papers appearing in AGRICULTURAL ENGINEERING, entitled "Soil Erosion Studies" by W. D. Ellison, provides an object lesson in getting down to genuine basic fundamentals in agricultural engineering research.

For years it has been generally accepted as practically self-evident that the primary object of soil and water conservation was to hold precipitation at or somewhere near the ground surface on which it fell, to limit and delay its surface flow, and to minimize the obvious and measurable damage caused by uncontrolled surface flow. And a lot of excellent research and application of knowledge derived therefrom have been devoted to this end with good results.

Meanwhile the apparently innocuous little raindrop, its energy of impact, and the immediate effects of its impact were largely ignored. The impact of raindrops on a man's hand is less noticeable than their wetting and temperature effects. Small wonder that it might seem insignificant to engineers trained to think of energy in terms of multiple horsepower. Precipitation causes apparent impact damage only in the case of hail, and then the evident damage is to crops rather than to the soil. What matter if some particles of surface soil are bounced into the air by raindrops, only to fall again within a few inches of their previous position?

Actually it has been found to matter considerably, now that someone has stopped taking this phenomenon for granted as insignificant, and has made it the subject of some intensive research!

It is not our purpose to elaborate on the specific research results and their significance, being ably presented by Mr. Ellison. We do want to call attention to their further significance as an indication that in any research problem in agricultural engineering, there may be factors seemingly as insignificant as raindrops, and as easily overlooked, but which actually merit detailed consideration in analysis of the problem. Research should be understood to imply and include the careful re-evaluation of factors which may have been overlooked, unidentified, wrongly identified, taken for granted, considered insignificant, or otherwise not fully exploited in the pursuit of knowledge.

"It Can't Happen Here"

TO THE EDITOR:

LOOKING at the August issue of "Tool Engineer," published by the American Society of Tool Engineers, I was most interested in the above-titled editorial by President W. B. Peirce of that society. You may want to use this in AGRICULTURAL ENGINEERING to show the interest of tool engineers in farm production. . . . It is well written and undoubtedly will make agricultural engineers realize more fully the importance of their work. The editorial follows:

Freedom from fear of famine is one of the choicest blessings of life in the United States today. And, as with most truly great blessings, we tend to take it for granted. The word "famine" paints a horrible picture of great suffering before our mind's eye—a picture of something that has happened at some other time, in some other place. We accept our national food supply as a certainty. Famine just can't happen here. But why can't it?

. . . . It is not just one summer's harvest that insures our food supply. It is the technological progress of the past 75 years which helps increase the bounty of the harvest and which enables us in the "years of plenty" to store up food for the lean years.

Improvements which have transformed farming from a way of life into an industry have made famine-producing crop failures very nearly impossible. They have armed our farmers with scientific weapons for combatting the once inevitable raids of the natural foes. Irrigation, soil conservation, use of fertilizers, pest and disease control have resulted in greatly increased productivity. Mechanization of farm tools has made possible more intensive cultivation with the use of a greatly reduced labor force. These factors, combined with unusually favorable weather, resulted in an increased agricultural yield that was one of the most spectacular of the country's war production achievements. In the five-year period, 1939-1944, farm output shot up 25 per cent, while agricultural employment actually declined and the acreage under cultivation increased only six per cent.

Developments in the fields of handling and transportation are a major reason why famines can't happen here. In history's record of Biblical times, we find that it was not unusual for people in one section of a country to be starving while those in another part of the land, where crops had flourished, had plenty. But there was no means by which the food could be moved in appreciable quantities from the land of plenty into the stricken area. Today, with the railway, motor, water and air transportation facilities available to the American people, famine cannot exist in any part of the country. No section need even be short of one luxury food item for any length of time.

Not only has our improved transportation system made possible equitable food distribution, but it brought about changes in the nation's eating habits which have made us a healthier people. Fresh fruits and vegetables are rushed from truck gardens and farms to rural and urban markets by huge fleets of trucks—and sent over longer distances in the refrigerator cars of fast trains. Low hauling charges and high food production bring a wide variety of foods to the corner grocery of every community at prices within the income of nearly every family. Oranges, which were in the Christmas gift class not many years ago, are now a routine item in most American breakfast menus. The 1924 per capita orange consumption of 21 pounds was a peak—but by 1938 the average was 38 pounds. Consumption of the healthful citrus fruit family as a whole increased from 18.2 pounds in 1909 to 62.4 in 1939. Within a decade consumption of fresh asparagus, grapefruit, lettuce, celery and similar produce was doubled.

Easy availability of these and other foods on a year-around basis has resulted in a shift of emphasis in our diets and, consequently, in the quantity of certain food items produced. By 1939 we were eating 14 per cent less carbohydrates, 10 per cent less protein and 5 per cent fewer calories than in 1909. In their place we were consuming more of the so-called "protective" foods—eggs, dairy products, fats, fruits and vegetables—foods made generally available by improved transportation and *(Continued on page 424)*

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The Fundamentals of Mechanical Tree Planter Design and Performance

By H. D. Bruhn and F. B. Trenk

MEMBER A.S.A.E.

WHILE it has long been recognized by foresters and others concerned with the promotion of forestry that vast areas of our country would be suitable for tree production and available as well, the back-breaking, time-consuming, and expensive operation of hand planting has discouraged and retarded such interests.

During the depression years of the early 1930's, with alarming amounts of labor available, thousands of acres were reforested by hand planting financed by federal funds. Although millions of trees now stand as living memorials to the work of the Civilian Conservation Corps, this program was only a temporary mitigation of the difficulties involved. It did, however, serve as a stimulus to develop nursery capacity of considerable magnitude. In the spring of 1943 the Wisconsin Conservation Department was faced with a potential surplus in its forest nursery, for the war had greatly reduced available manpower for planting trees.

Therefore, in the summer and fall of 1943 the agricultural engineering department of the Wisconsin Agricultural Experiment Station began work on the design and construction of a planting machine that would operate efficiently in light soil. A planting unit built around a single-bottom, trailing-type tractor plow appeared to offer the most desirable qualities obtainable with available equipment.

Using as a model our most successful unit, the Wisconsin Conservation Department acquired 14 second-hand tractor plows, and at its forest protection machine shop constructed planting machines from this mixed assortment of cast-off farm equipment. A paper company engaged in a forest management program built another. The state sold some of the machines to county forestry departments and county soil conservation districts, retaining a few for operation on state land. In all, 16 machines were in operation during the spring of 1944, planting close to 4,000,000 trees. The prospective surplus of trees at the state nursery did not materialize. The thorough test of mechanical tree planting over the past three years emphasized the line along which development should proceed and also indicated many fundamentals of design and operation.

Elements in the Design and Function of Mechanical Tree Planters. Sufficient progress has been made in testing tree-planting machines of different design and types to warrant a brief summary of the design and performance of various elements of the planting mechanism, as follows:

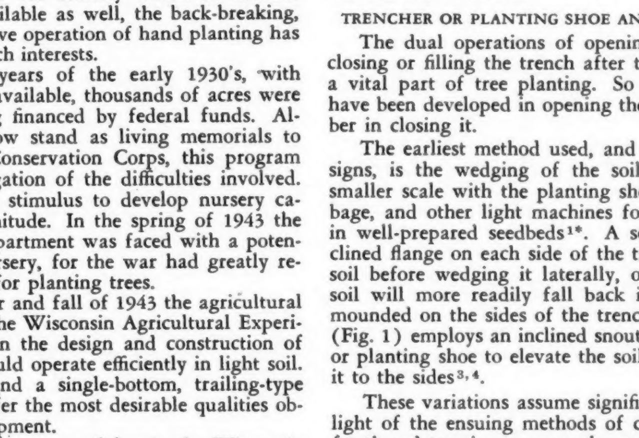


Fig. 1 The middle-breaker plow bottom and planting shoe of the first successful Wisconsin tree-planting machine. The middle-breaker bottom is obtained by mounting one conventional right-hand moldboard plow bottom together with a similar left-hand bottom. It was found that 14-in bottoms equipped with 12-in shares produced the most desirable furrow. The rolling coulter equipment shown here is not sufficient for cutting a heavy, deep root growth. Proper coulter equipment is shown in Fig. 4

TRENCHER OR PLANTING SHOE AND THE PLANTING TRENCH

The dual operations of opening the planting trench and closing or filling the trench after the tree is set are obviously a vital part of tree planting. So far three distinct methods have been developed in opening the trench and an equal number in closing it.

The earliest method used, and still employed in some designs, is the wedging of the soil laterally, as occurs on a smaller scale with the planting shoe of tobacco, tomato, cabbage, and other light machines for transplanting field plants in well-prepared seedbeds[1]*. A second design entails an inclined flange on each side of the trencher to slightly raise the soil before wedging it laterally, on the theory the displaced soil will more readily fall back into place after being thus mounded on the sides of the trench[2]. The Wisconsin planter (Fig. 1) employs an inclined snout at the front of the trencher or planting shoe to elevate the soil out of the trench and spill it to the sides[3,4].

These variations assume significance when reviewed in the light of the ensuing methods of closing or filling the trench, for they determine to a very large degree the manner in which the soil comes in contact with the roots of the planted tree.

The planting shoe that simply wedges the soil apart is usually followed by heavy press wheels that are designed to press together the two walls of the trench. In light soil this is relatively easy; in root-bound or somewhat heavy soil there is a strong possibility of incomplete closing of the trench with root damage caused by the voids or air pockets that are left. If the trench is completely closed, the roots of the planted trees are compressed between two firm vertical planes which the roots must penetrate for subsequent growth. Disks have been employed directly behind the trencher to throw loose soil into the trench around the roots, before they are packed into place by the press wheels[1]. If there is sod or loose, dry litter along each edge of the trench, the efficiency of the disks is greatly reduced. When soil is elevated out of the trench and is spilled at the edge of the trench[4], it is extremely simple to "flow" the soil back into place through the use of cover plates. In this process much loose soil is spilled

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

H. D. BRUHN is associate professor of agricultural engineering, and F. B. TRENK, extension forester, University of Wisconsin.

*Superscript numbers refer to appended references.

into the trench, and the roots are completely surrounded by a zone of soil of uniform but not too compact structure. At no time do the roots find it necessary to penetrate a compact vertical plane. Examination of trees planted in this type of trench revealed uniform growth of roots in all directions during the first growing season.

At first it might be presumed that a blunt snout (Fig. 1) 4 in wide on the front of the trencher or planting shoe would greatly increase the draft of the planter. This is not the case, for the simple reason that less power is required to elevate soil on an inclined, polished plane than to wedge it laterally against soil that is already relatively compact. Furthermore, the inclined snout produces sufficient vertical suction to facilitate the quick and positive penetration of the planting shoe. A shoe, such as that used on tobacco and cabbage transplanters, without vertical suction penetrates very poorly in an unprepared seedbed; and if penetration is secured by sufficient vertical loading, the draft becomes very high.

The planting shoe or trencher should be at least 8 in deep and should open a trench not less than 3.5 in wide. Greater width and depth may be required for special planting jobs. It is desirable that the shoe be relatively short in over-all length in order to reduce bending stresses when the machine is operating on a curved path.

No part of the tree-planting machine will be subject to more abrasive wear than the trencher. Some parts of it will be subjected to more abrasion than others. It is essential that all parts subject to abrasion be of soft-center or crucible steel, and, further, that these parts be so designed and attached that they can be replaced quickly and economically with new parts.

The accompanying figures show, in experimental sequence, the major steps in the development of the Wisconsin trencher and planting shoe, and their relation to the complete tree planting machine.

Fig. 2 shows diagrammatically the runner-type planting shoe and its position with reference to the middle-breaker-type plow which removes the sod and trash ahead of the planting shoe. The middle-breaker-type bottom is provided by mounting one conventional right-hand moldboard plow bottom together with a similar left-hand plow bottom. While this type of planting shoe is widely used on corn planters, grain drills, and various transplanters for cabbage, tobacco, etc., it is practically worthless as a tree-planting shoe in any soil more firm than a well-prepared seedbed.

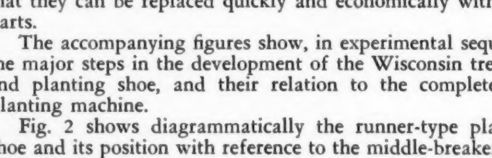
Since it was immediately obvious that the penetration of this shoe would be unsatisfactory in normal tree-planting situations, a trencher was added to the middle breaker as shown in Fig. 3. This trencher, for all practical purposes, prepared the seedbed for the shoe which followed. Furthermore, the inclined front surface of the trencher produced desirable vertical suction. Some vertical suction is required to give penetration of the planting shoe even when running in a prepared trench; and, furthermore, since the middle-breaker bottom is often run quite shallow, vertical suction beyond that given by the regular shares is desirable to maintain a uniform depth.

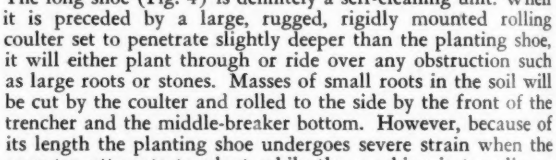
The third stage in the development of the trencher and planting shoe was the combination of the two into one unit as shown in Fig. 4. The single unit gave more structural stability and shortened the over-all length; and because the trencher and shoe were built as a box section just slightly wider at the front than at the back, a rather light running shoe was produced which gave no difficulty in penetration. To date, practically all of the machine-planted trees in Wisconsin have been planted with the type of planting shoe shown in Fig. 4.

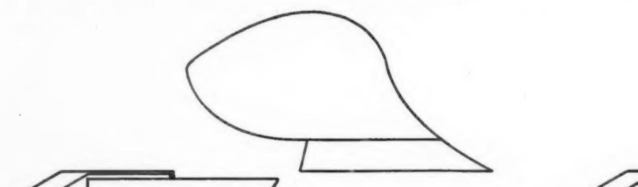
A more recent development has been the shoe shown in Fig. 5, which is a shortened version of the shoe shown in the previous figure. The shortened shoe is used in a commercially produced planter (Fig. 7).

Each shoe has some advantages and some disadvantages. The long shoe (Fig. 4) is definitely a self-cleaning unit. When it is preceded by a large, rugged, rigidly mounted rolling coulter set to penetrate slightly deeper than the planting shoe, it will either plant through or ride over any obstruction such as large roots or stones. Masses of small roots in the soil will be cut by the coulter and rolled to the side by the front of the trencher and the middle-breaker bottom. However, because of its length the planting shoe undergoes severe strain when the operator attempts to plant while the machine is traveling a rather abrupt curve. Furthermore, the soil removed by the trencher is thrown to the sides with the sod furrow and is not available for refilling the trench.

The short shoe (Fig. 5) of course negotiates curves with







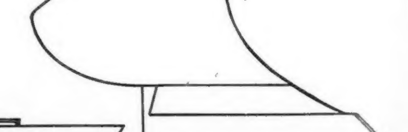


Fig. 2 *(Upper left)* The middle-breaker bottom and runner-type planting shoe. This type of shoe gave very poor penetration in any soil more firm than a well-prepared seedbed • Fig. 3 *(Upper right)* By the addition to the middle breaker of a center fin widened at the front end to a width equal to that of the planting shoe, good penetration was possible even in very firm unworked root-bound soil • Fig. 4 *(Lower left)* By moving the planting shoe forward and extending it through beyond the front of the share a very rigid self-cleaning planting unit is accomplished that will penetrate very well. This machine has the disadvantage of throwing the soil removed by the planting shoe away with the furrow slices, but when preceded by a large coulter will ride over stones or roots too large to cut • Fig. 5 *(Lower right)* By shortening the planting shoe the unit is more maneuverable and has the further advantage of spilling the soil removed by the planting shoe in the bottom of the furrow where it can be raked back by the cover plates to refill around the tree roots. It does not, however, free itself of roots and trash as well as the shoe shown in Fig. 4

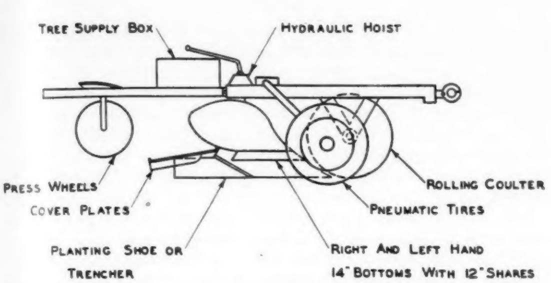


Fig. 6 A complete tree-planting machine incorporating such desirable features as self-cleaning planting unit, large rolling coulter, hydraulic hoist, and pneumatic tires

less difficulty and elevates the soil removed from the planting trench to a position where it can be easily used for refilling around the planted trees. However, clogging can easily occur where the inclined plates on the trencher elevate the soil under the middle-breaker bottom. Roots and trash in the soil tend to aggravate this difficulty. Furthermore, because this unit cannot readily be combined with a large, rugged rolling coulter immediately in front of the point of the trencher, it does not ride over buried obsructions. The trencher which is set back of the point of the middle breaker can easily catch on a large root. This causes difficulty because the planting shoe is open at the rear, and backward motion is, therefore, undesirable.

The long shoe has recently been modified as shown in Fig. 6. The front section of this shoe is narrower than the rear section. The full width section begins at the inclined planes about halfway back on the shoe. This construction gives nearly the same self-cleaning characteristics as the shoe shown in Fig. 4 and still allows a major portion of the soil removed from the planting trench to flow back and be raked in by the cover plates.

In compact or dry soil, difficulty is experienced in obtaining penetration of the large rolling coulter; therefore, under these conditions a standing coulter must be substituted for the rolling coulter. A standing coulter, of course, will not ride over large rocks or roots too large to cut through, so with its use considerable care must be exercised in adjusting the safety spring-release hitch.

THE MIDDLE-BREAKER PLOW FOR SOD OR BRUSH REMOVAL

Whether or not the land is furrowed as part of the planting operation is apparently a question of regional conditions, depending upon presence or absence of seriously competing vegetation and a shallow or deep layer of top soil. The factor of sunscald caused by heat radiating from exposed soil is considered important. Certainly where soil is cultivated before

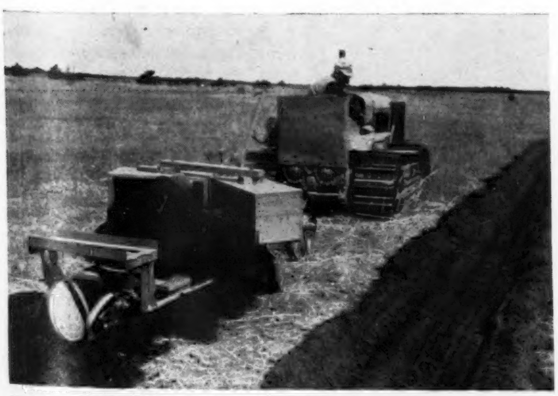


Fig. 8 Two men with a tractor and one of the early experimental machines reforesting worthless farm land at the rate of sixty trees a minute at 6-ft intervals and 6-ft row spacing. The tractor operator checks the tree spacing, and if the trees appear too close, he drives faster. (Photo courtesy of Frank Fixmer)

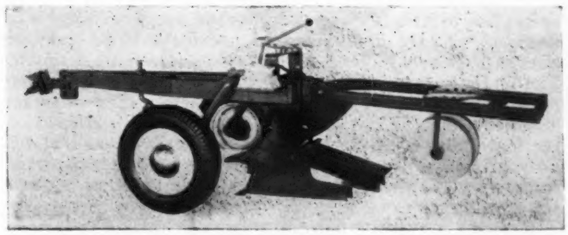


Fig. 7 The complete commercially produced tree-planting machine. The extra seat is available where an additional operator can ride and prepare tree seedlings for the operator who sets the trees. (Photo courtesy of Wagler Equipment Co., Pewaukee, Wis.)

planting, as in the prairie states, furrowing is unnecessary. In the central and lake states, where sod, even on old fields and on burns is prevalent and summer droughts are the rule rather than the exception, furrowing has long been accepted as an essential requirement. Apparently in the north Atlantic states, where rainfall is heavier, sod is not so detrimental to young plantations, although the experience of one of the authors in tree planting in the Piedmont section of Maryland showed that furrowed plantations were desirable. In the coastal plains of the South, foresters who have observed furrowing report that it is unnecessary due to relatively thin sod, shallow surface soil, and the hazard of sunscald in furrowed plantings.

It is relatively easy to make the middle-breaker plow as optional equipment on tree planting machines.

ARTICULATION BETWEEN THE PRESS WHEEL ASSEMBLY AND THE PLANTING CHASSIS

Three choices are open to the planting machine designer in attaching the chassis carrying the press wheels and the operator's seat to the main frame of the planter. It has been made an inflexible part of the planter[2,4], it has been made to hinge vertically only[3], and in our experiments it was found that a coupling which permitted free movement in both the horizontal and vertical plane was most satisfactory.

The advantages of the latter arrangement have been found to outweigh the disadvantages. Press wheels will follow with less rolling onto the planted trees when planting in irregular or curved rows, and there is less likelihood of bending or twisting the press wheel assembly in turning at the end of the rows or in dodging large stumps or rock formations when the press wheel assembly is free to caster. If difficulty is experienced with this arrangement when operating on a side hill where the press wheel tends to slide to one side and run over the trees, tie rods can easily be connected between the main planter frame and the press wheel chassis.

HOISTS

A basic requirement for efficiency in planting operations is a means of quickly lowering the shoe into the ground and retracting it at the end of a row. Three types of equipment have been used: The standard power lift and trip used on the trailing-type tractor plow, the hydraulic hoist, and the lever or screw-jack adjustment. While the conventional power lift is the most rapid in retracting the shoe, its principal deficiency is that it requires forward motion to function. Sometimes forward motion is made impossible by a buried obstruction, and much time is likely to be lost in disengaging and retracting the shoe as reverse motion is impossible. The hydraulic hoist permits immediate vertical retraction when the planter is not in motion, and has the added advantage of providing at all times a means of making instant adjustments in the depth of the planting operation as variations in soil texture and cover may be encountered. The lever or screw-jack types of lifts have most of the advantages of the hydraulic hoist with the exception that they require much physical effort and thus tend to slow the planting process.

MOBILITY

Since tree planting is carried on in widely scattered and rather remote areas, it is essential that tree-planting machinery

be readily moved from one location to another. Thus it is necessary to have it mounted on pneumatic tires; standard sizes such as 6.00-16, 7.00-16, or 7.00-15 are highly desirable. The larger sizes are preferable because of the better flotation obtained on light soil. The wheels on which these tires are mounted should be carried on hubs equipped with antifriction bearings and with grease and dust seals as well, so that the machine may be operated on sandy soil and yet be transported at rather high speed from one location to another without excessive wear.

MULTIPLE USE

In the northern states the planting season is relatively short, and therefore a planting machine is operated but a few weeks each year. Some forest management units, such as town and county forest departments, as well as industrial enterprises, have need for additional forestry equipment, including firebreak plows. A planting machine of relatively heavy construction, having a middle-breaker plow as standard equipment and with a planting shoe that may be detached readily, becomes for the balance of the year a firebreak plow, thereby making an investment in a piece of forestry machinery cover a wider field of usefulness.

Commercial Production of Planting Machinery. Our experience over the past years has indicated the practicability of mechanical tree planting. It has also indicated the inadvisability of the building of so-called homemade machinery. At the present time one manufacturer is producing planting equipment employing many of the desirable basic principles first worked out in our experimental machines (Fig. 7).

Limitations to the Use of Planting Machines. Power-operated tree-planting machines, operating on the principle of opening a continuous planting trench, face definite limitations in general application. Stoniness of the soil, steepness of grade, occurrence of large tree roots and stumps, and heavy colloidal content of soils are factors, listed in descending order of relative importance. Any of these conditions in extremes can rule out the economic operation of planting machines. Nevertheless, there are tremendously large areas of relatively level, sandy to easily friable soils (including the soils of the Great Plains shelterbelt project area), free from stones and large roots, and suitable for timber production, on which mechanical tree planting offers to make reforestation more economical than hand planting could possibly be.

Planting Costs and Survival. The most efficient planting crew consists of three persons — one to operate the tractor, one to set the trees, and one to sort and have trees ready for the tree setter. Boys and women have handled these jobs very efficiently. If it is to be assumed that for hand planting furrowing would be a required preparation, then not all of the tractor operating costs should be charged as incidental to machine planting in comparative planting cost studies. It is true, however, that a tractor engaged in furrowing only (to be followed by hand planters) will operate about twice as fast as one pulling a tree-planting machine. The most satisfactory rate of travel for a machine setting trees at 6-ft intervals is between 2 and 2.5 mph.

The following records on operations were submitted by Frank Fixmer, forester for the Mosinee Paper Company. The planting was done on relatively open land in Douglas County, Wisconsin. The area planted each year was a little less than 200 acres.

Costs (per acre of approximately 1,000 trees)	1944 (Hand planting)	1945 (Machine)	1946 (Machine)
Labor	$5.52	$1.36	$1.76
Tractor rental and operation	1.67	2.57	2.74

These figures do not include depreciation on the machine, nor initial cost of planting stock. The machine used on this job was one of the original second-hand plows converted to a planting machine. It was junked after planting 500,000 trees. Original investment and repairs amounted to $200. A depreciation of 40c per 1000 trees should therefore be added to the above-reported machine costs. Heavier machines newly constructed can be expected to plant not less than two million and, with reasonable care and replacement of shoe parts, may plant a great many more. A depreciation figure of 25c per thousand trees is therefore assumed to be conservative. There were substantial increases in hourly wage rates between 1944-45 and between 1945-46, so the hand labor figure for 1944 should be increased by not less than 35 per cent to show a more accurate comparison between hand and machine planting in 1946.

A planting-machine operator employed on a custom job estimated he increased his daily planting output by at least 20 per cent when he eliminated the need for stopping at the end of each row and turning around. Operating in a 40-acre field, he began spiral rows around a circle about 250 ft in diameter in the center of the field. While there was a slight irregularity in the rows as he approached the corners when completing the job, the tree spacing was sufficiently close to provide a fully stocked stand.

Certain skills are required on a machine to produce uniformity in spacing, to set roots at the proper depth, to control flow of soil into the trench, and to have the planted trees in a vertical position after the soil has been packed by the press wheels. The alert operator frequently checks these factors until he is satisfied he has become proficient. Failure to do so can result in low survival of planted trees. Where real skill has been developed, survival in machine-set plantations in Wisconsin has been remarkably high. A survival check was made on a 25,000-tree plantation set out by the Mosinee Paper Company in May, 1946. The stock was 4-year-old Norway pine transplants. The soil was sandy, and the planting was done during a pronounced spring drought. An experienced and careful operator set the trees. In September it was not possible to find a dead tree in the plantation, and all of the trees had made a most satisfactory growth during the previous three months. Obviously the stock was of excellent quality, but losses in hand-set plantations in the same locality ran from moderate to severe.

Influence of Mechanical Tree Planting on Wisconsin Forestry. Although it is recognized that there are substantial areas within the state which can be reforested only by hand methods, the advent of tree-planting machines has already developed definite and favorable trends in forest development within the state (Fig. 8). These trends embrace all classes of forest owners — industrial, farm, estate and absentee owned, community, county, and state.

At present two paper corporations engaged in extensive forest planting projects operate a total of six planting machines with an annual planting capacity of over two million trees. An official of one of the companies reports that per acre planting costs are now down to those experienced in 1935, practically the lowest in the company's experience. Six counties owning county forest reserves have planting machines in operation, and additional counties will have machines within a year. In two state forests machines are being used on suitable soils.

There are even more encouraging developments among the owners of relatively small tracts of land. Nine counties organized as soil conservation districts have tree-planting machines available for rental to farmers or other landowners where the land is adapted to machine planting and the number of trees to be planted warrants the time and expense involved in transporting the planting machine. Generally 5,000 trees have been set as a minimum. The landowners are required to furnish power and labor. Service charges for the use of the machines range from 70c to $1.25 per thousand trees planted.

Ultimately this is a service that should be handled on a custom basis. Most communities and soil conservation district officials generally encourage private ownership of machines. Several machines are now operating in the state on a custom basis with the county officials acting only in an advisory capacity since they are most fully informed on the names and locations of landowners who want to be assured of mechanical planting service before they agree to buy the trees.

Public attitude on tree planting as an investment has undergone a favorable change in many communities where mechanical tree-planting service is available. This is true of both resident and non-resident owners. (Continued on page 396)

Engineering and Agronomic Phases of Mulch Culture

By G. B. Nutt and T. C. Peele
MEMBER A.S.A.E.

FARMING methods designed to leave a considerable portion of the residue from preceding summer or winter crops on the soil surface as a mulch during the growth of row crops or small grains have been proven agronomically feasible and practicable for the Piedmont soil provinces. Maintaining crop residues on the soil surface is a much more effective method of reducing runoff and erosion from areas where corn or small grains are growing than plowing the residues under and using conventional clean tillage practices. Also, short-time trends indicate that the mulch-farming practices cause greater improvement in soil aggregation and a more rapid increase in soil organic matter and nitrogen in the 0 to 5-in soil depth than conventional methods.

Knowledge of these advantages of mulches has been used as a basis for developing cultural techniques and machinery that make mulch farming practical for the farmer.

Since the invention of the steel moldboard plow more than a century ago emphasis has been placed on turning under vegetation, rather than leaving all or a part of it on the soil surface. Very few tillage tools have been developed specifically for leaving crop residues on the soil surface, and the problem facing the engineer is to design, develop, and in some cases, adapt conventional tools suited to this purpose.

Piedmont soils present many tillage problems familiar to engineers due to the presence of rocks, poor shedding qualities, and their tendency to dry out rapidly after being thoroughly wet. The tractor moldboard turning plow, never a success in this area, has been supplanted by disk-type plows. Therefore, the effort expended in developing tools for mulch farming is not renewing the controversy that has existed in some areas about the merits of the moldboard turning plow. It is rather an endeavor to develop tools that will till the soil and leave a maximum of plant residues on the surface to conserve soil and moisture.

Row-crop experiments at Clemson on Cecil sandy loam have involved the use of winter and summer cover crops as sources of mulch.

The preparation of the land for corn is started about the first of April, and the corn is planted about two weeks to a month later depending on weather conditions. Where winter cover crops follow corn, a considerable amount of cornstalk residue is present to protect the soil against erosion until the cover crop growth is established (Fig. 1). By April these winter cover crops have almost reached their maximum growth and must be thoroughly killed before planting corn.

Three tillage methods with corn have been compared where corn was grown following vetch and rye or crimson clover: (1) mulch balk method, (2) mulch disk method, and (3) plowed, clean cultivation. These methods have been compared for the past four seasons but tools and techniques have varied as developments warranted.

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Biloxi, Miss., January, 1947.

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Fig. 1 View of cornstalk litter after drilling in vetch and rye

The mulch balk method has consisted of opening clean planting furrows through the residue at $3\frac{1}{2}$-ft intervals. Two to four weeks prior to planting, the balk is loosened with a mulch-type sweep similar to the one shown in Fig. 2. Attachments for tractor cultivators were first used for forming the planting furrows but were discarded as unsatisfactory. The development that followed, and is considered most satisfactory, is a modified middle-buster as shown in Fig. 3. The moldboards are removed and the frog cut out. A rolling coulter is mounted ahead of the share, and following the share disk hillers are set to operate shallow and push the soil out so as to open up the furrow without covering the vegetation. Any standard tractor middle-buster may be modified for this operation. This equipment is pictured in operation in Fig. 4.

A standard tractor planter with fertilizer attachment is used for planting in the furrows made with the middle-buster shares. In extremely heavy mulch, disk hillers should be mounted to open up the furrows as shown in Fig. 5.

In 1946 a rotary hoe was used for the first cultivation, and a conventional sweep cultivator was used for the second, third, and final cultivations. Sweeps adjacent to the plants were of varied sizes depending on heights of the corn, but the ones operating in the balks were regular 14-in sweeps set to run flat. Pressure springs on the rear cultivator rigs were required for satisfactory performance. Thorough loosening of the balk with a mulch-type sweep must precede the cultivation with regular cultivator equipment.

Several attachments for cultivating mulch balk corn were tried prior to using the equipment described above. The three-row mulch plow in Fig. 6 was tested extensively in 1944 and was not entirely satisfactory. This type of mulch sweep was one of the best tested, but a three-row plow does not work out satisfactorily where two-row equipment is used for planting.

Modified peanut digger blades and gage wheels mounted on a standard cultivator as shown in Fig. 7 were also tested in 1944. Rocks, hard soil, and the tendency to clog prevented satisfactory operation of this combination for normal soil conditions.

The mulch disk method employs a cutaway tandem disk harrow heavily weighted and pulled slowly to kill the winter cover crop, loosen the soil, and leave most of the residue on the surface. In heavy growth on hard, dry, clay soil the disk gangs may be operated at full angle and moderate speed without incorporating an excessive amount of plant residue. On sandy soils the harrow should be pulled more slowly, and the gangs set about two-thirds of full angle.

The second operation consists of opening up planting furrows with the middle-buster shares described under the mulch balk method. The vetch and rye shown in Fig. 8, had been disked and furrows opened for planting corn. Cultivation equipment is also similar to that used with the mulch balk method, consisting of a rotary hoe and standard sweep cultivator equipment adjusted to operate in the mulch.

The plowing, clean cultivation method is the standard practice of plowing under cover crops with a disk plow and disking thoroughly. Planting furrows are also formed prior

to planting, and cultivation is done with conventional sweep equipment. Most of the cover crop is incorporated with the soil by this method.

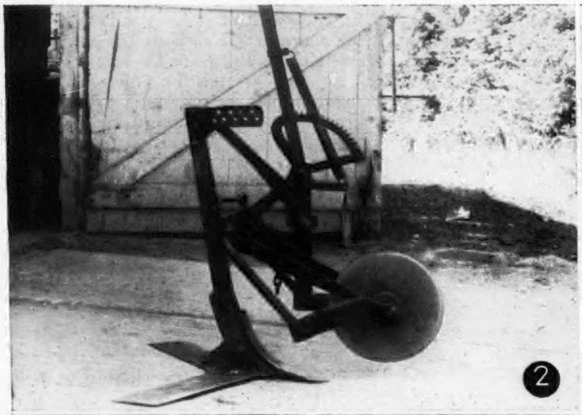
EFFECTS OF TILLAGE METHODS

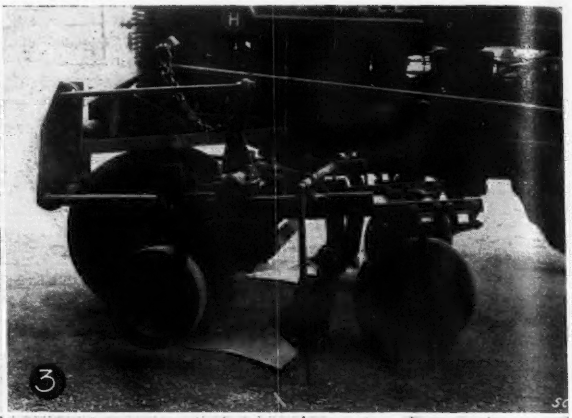
Tables 1, 2, and 3 show the effects of handling vetch and rye by different methods and give a comparison with the plowed no-cover-crop treatment.

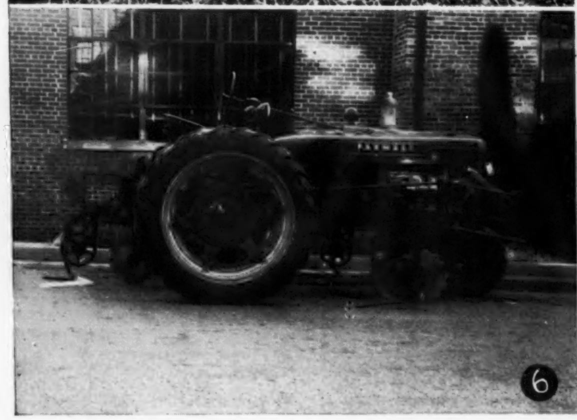
Unusual increases in yield for all treatments in 1945 and 1946 over 1943 and 1944 were due to changing from open-pollinated to hybrid corn and heavier applications of fertilizer. Differences in yields attributable to tillage methods following the vetch and rye are slight.

A summary of runoff and erosion given in Table 2 shows conclusively that the mulch methods are effective in reducing soil and water losses to low quantities. Mulch affords the greatest protection to the soil during flash floods which often occur in the Piedmont in July and August, as shown in Table 3, for a single rain of 4.46 in occurred in August 1946.

The influence of mulch-farming practices on soil structure and accumulation of organic matter as compared with conventional tillage methods may determine to a large extent the ultimate effects on soil productivity of such a change in farming methods. Mulch methods produced greater improvement in soil aggregation than clean tillage methods.







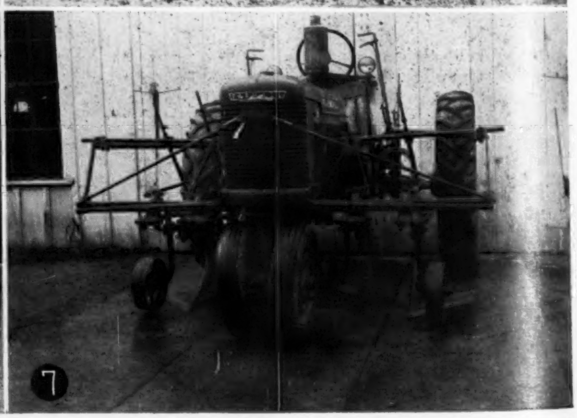


Fig. 2 Mulching attachment for a one-row middle-buster • Fig. 3 Furrow opener consisting of coulter, middle-buster share, cutout frog and disk hillers • Fig. 4 Establishing planting furrows in vetch and rye that has been double disked • Fig. 5 Standard two-row tractor planting equipment used in planting in mulched areas • Fig. 6 Three-row mulch plow developed for attaching to middle-buster tool bars • Fig. 7 Two-row mulch plow consisting of four peanut digger blades and gauge wheels

Fig. 8 Vetch and rye after double disking and opening planting furrows

Data obtained indicate that the mulch method is slightly the more effective in reducing runoff and erosion. Greatest gains in organic matter were produced by this method also. The mulch disk method, intermediate for the treatments, received thorough diskings the first two years, while in 1945 and 1946 the cover crops were disked just enough to kill them, leaving most of the plant residue on the soil surface. If this procedure had been followed the first two years, this tillage method might have approached the effectiveness of the mulch balk method in increasing the supply of organic matter retained in the soil.

CORN FOLLOWING SUMMER COVER CROPS

Summer cover crops such as Kobe lespedeza and Crotalaria spectabilis are good sources of mulch for row crops. Crotalaria may be broadcast in the corn at the last cultivation the first year and will usually reseed itself thereafter where corn is grown on the same land. These crops provide a source of dead residue in the spring that presents fewer tillage problems than winter cover crops, and there is less likelihood of insect damage to the corn plants.

TABLE 1. INFLUENCE OF TILLAGE METHODS ON CORN YIELDS

Tillage method	Cover crop	Corn yield in bushels per acre 1943	1944	1945	1946	Average
Mulch balk	vetch and rye	26	24	65*	69	46.0
Mulch disk	vetch and rye	30	22	80	63	48.8
Plowed, clean cultivation	vetch and rye	32	19	76	60	46.8
Plowed, clean cultivation	none	40	22	62	54	44.5

*Stand depleted by bud worms.

TABLE 2. AVERAGE ANNUAL RUNOFF AND EROSION DURING THE CORN GROWING SEASONS IN THE 4 YEARS, 1943-1946

Tillage method	Cover crop preceding corn	Runoff, per cent*	Erosion, lb/acre
Mulch balk	vetch and rye	4.56	490
Mulch disk	vetch and rye	7.36	1610
Plowed, clean cultivation	vetch and rye	13.88	2980
Plowed, clean cultivation	none	32.76	6200

*Percentage of total precipitation from all storms producing runoff.

TABLE 3. RUNOFF AND EROSION FROM CORN PLOTS DURING 4.46 IN RAINFALL, AUGUST 21-22, 1946

Tillage method	Runoff, per cent	Erosion, lb/acre
Mulch balk	4.8	173
Mulch disk	9.4	275
Plowed	27.7	662
Plowed, no cover crop	62.9	1767

TABLE 4. RUNOFF AND EROSION FROM OATS AFTER KOBE LESPEDEZA, 1944 - 1945

Tillage method	Runoff, per cent	Erosion, lb/acre
Mulch plowed; planted with disk drill	0.7	40
Deep furrow drill; no ground preparation	0.9	60
Disked thoroughly; planted with disk drill	17.7	2170

Data include all storms producing runoff during oats growing season.

EQUIPMENT AND TILLAGE METHOD RECOMMENDED FOR CORN PRODUCTION BY THE MULCH METHOD

The mulch disk method affords a practical way of producing corn and maintaining high yields while erosion and runoff are reduced to negligible quantities.

The following items of tractor equipment are required:

1 Heavy-duty, tandem disk harrow with provision for adding weight.

2 Middle-buster with rolling coulter attached, moldboards removed, frog cut out, and disk hillers attached and adjusted to open up the planting furrows.

3 Conventional planter (preferably front mounted for contour cultivation).

4 Rotary hoe (desirable but not necessary).

5 Conventional cultivator (preferably front mounted for contour cultivation with pressure springs on rigs and wide assortment of sweep sizes).

Winter cover crops should be killed by disking when they have attained sufficient growth. The weighted harrow should be pulled at reduced speed and less than full angle to leave the maximum amount of vegetation on the soil surface. This operation should precede planting two to three weeks. The planting furrows may be made at planting time or a few days prior to planting.

The rotary hoe may be used one or two times depending on soil moisture conditions.

Cultivator adjustment and sweep sizes will also be influenced by soil conditions and growth of the corn. The center sweeps should be set to run flat. Ordinarily two cultivations with sweep equipment will be adequate.

All of the equipment is standard, but the middle-buster must be modified to form the planting furrows. This is a simple job with a cutting torch and by purchasing additional frogs, it may be reconverted to its intended use.

MULCH EXPERIMENTS WITH OATS FOLLOWING LESPEDEZA

A limited amount of work has been done on the utilization of lespedeza residue in grain production. Results from one of these tests are shown in Table 4. Runoff and erosion were in inverse order to the quantity of plant residue left on the surface of the soil by the tillage operation. Yield data indicate that lespedeza mulch can be used for controlling erosion without reducing yields.

PUBLIC ACCEPTANCE OF MULCH FARMING PRACTICES AND MACHINERY DEVELOPMENT

The more progressive farmers of the Piedmont and upper Coastal Plains are cognizant of soil erosion and are seeking methods of control. Changes in tillage practices may be developed experimentally by farmers as well as engineers. Such has been the case with machinery development in this area for leaving plant residue on the soil surface. For example, farmers have discovered means for planting grain in stubble to utilize the undisturbed residue for controlling erosion. Field tillers are being widely used for fall and spring plowing in stubble. This type of implement is limited in use and should be provided with rolling coulters for trashy conditions and modified to be more flexible for use on contoured land.

New machinery such as a cutoff corn picker for shredding the stalks while picking the ears will provide a source of mulch and aid in the control of insects. Many tillage and harvesting tools now in use may be used without modification for mulch culture. Others such as the middle-buster furrow opener may be developed from standard tools. There has not been a radical approach to the machinery requirements in the work reported herein. On the contrary, existing tools have been adapted to this system where it was possible to do so.

Machinery for Applying Anhydrous Ammonia to the Soil

By Felix E. Edwards and W. B. Andrews
MEMBER A.S.A.E.

IN 1943 work was started on the use of aqua ammonia as a source of nitrogen by the Mississippi Agricultural Experiment Station. Even though the equipment used was inadequate, the response of crops to aqua ammonia was satisfactory. In 1944 work was started on the use of anhydrous ammonia as a source of nitrogen, and the work is still under way. The Tennessee Valley Authority and the Mississippi Agricultural Experiment Station are jointly financing the project. From the standpoint of TVA the work which is under way in Mississippi is for the region.

Anhydrous ammonia is the first product made in taking nitrogen out of the air in recent synthetic nitrogen plants. During the war there were more than 20 plants producing ammonia in this country.

Ammonia may be used to make urea, nitrate of soda, ammonium nitrate, or other sources of nitrogen for crop production. Processing ammonia to make other sources of nitrogen increases the cost of the nitrogen. Work was started on the use of ammonia as a source of nitrogen for crop production because it appeared to offer a means of getting nitrogen at a lower cost.

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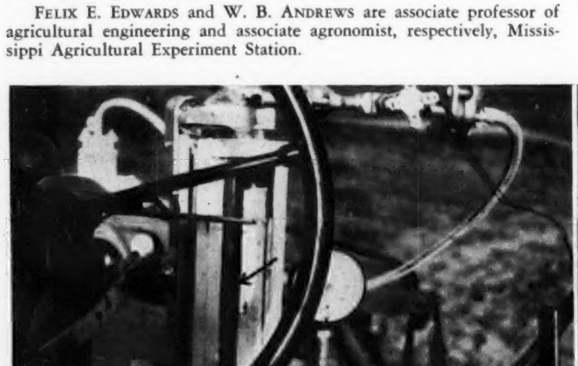
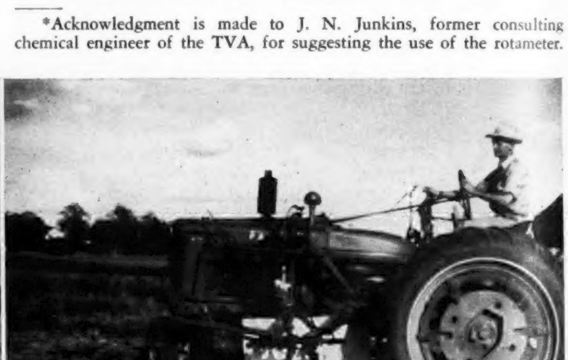
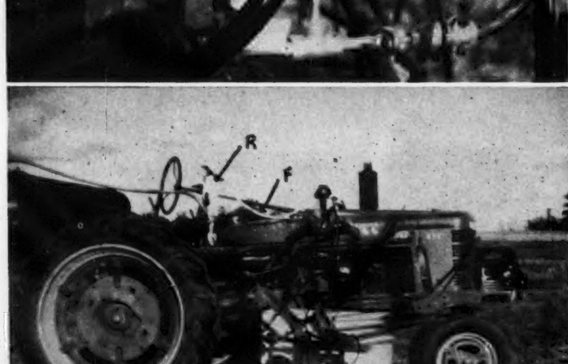
Since 1931 Shell Development Company of California has been using anhydrous ammonia in irrigation water for practically all crops. In 1939 Floyd Leavitt developed the first machine to apply anhydrous ammonia to the soil. The patent (No. 2,285,931) on this horse-drawn machine was assigned to Shell Development Company. Later this company developed a tractor-mounted machine which carries two protective patents against the use of anhydrous ammonia by the farmer. One of these patents covers metering devices; the other covers the protection of the applicator shank from wearing by the shield of ice formed over it. It is understood that Shell Development Company applied ammonia to approximately five thousand acres with their machines last year.

The Mississippi Agricultural Experiment Station was unable to get the equipment used by Shell to put out test plots. Consequently the development of equipment was undertaken.

Machinery Construction. The parts of the equipment are (1) tank, (2) strainer, (3) feed line, (4) pressure gage, (5) rotameter, (6) distribution lines including manifolds, (7) applicators, and (8) covering devices.

The first equipment developed was a one-row machine which consisted of a side-mounted, standard 100-lb anhydrous ammonia tank, Atlantic seamless steel high-pressure hose feed line, rotameter* and mounting, control globe valve, distribution line, and applicator shank. The equipment was mounted on a Model H Farmall tractor equipped with a two-row culti-

*Acknowledgment is made to J. N. Junkins, former consulting chemical engineer of the TVA, for suggesting the use of the rotameter.

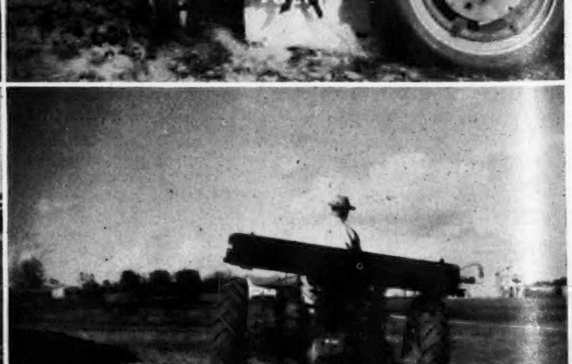


Fig. 1 The rotameter, mounting (fastened to steering column), connections, control valve, and arrow which points to rotar float in metering tube • Fig. 2 The first and third types of applicators with anhydrous ammonia being released into the air. The applicators have frosted over. • Fig. 3 Arrow R points to rotameter, arrow F to feed line. The second and fourth types of applicators with disk hillers set back of the second type • Fig. 4 The machine in operation applying anhydrous ammonia to the soil

vator. Later two-row equipment was developed which is described below along with equipment for four rows.

During the summer the tank mounting was changed to the rear of the tractor to facilitate loading of 150-lb capacity, standard anhydrous ammonia tanks. The mounting was built so that the tank had a 3-in fall to the outlet connecting to the feed line. The fall is necessary to insure the flow of liquid at all times. The mounting was bedded 2 in to support the tank. Two straps over the top of the tank hold it in the mounting. These straps are hinged at one end, and the other ends are dropped through slots which permits quick changing of the tanks. It is necessary that the pipe screw connection to the tank be very tight to prevent leaking. Flange-type unions are used where feasible to facilitate making and breaking connections.

In the ⅜-in feed line, a strainer with 1/64-in holes is located 4 in from the tank. The tanks were old and had iron scales in them which might have choked the distribution orifices if the strainer had not been used. Anhydrous ammonia has a very high pressure, ranging from 125 to 250 psi under normal temperatures encountered in the field. These pressures require a high-pressure feed line from the tank to the rotameter. The first line used was a ⅜-in Atlantic seamless flexible metal hose, which was tested to 300 psi. This type hose is satisfactory, except vibration soon caused it to leak. During the past year the metal hose has been replaced with 800-lb test, ⅜-in rubber hose. It is preferable that the end clamps be put on the rubber hose at the factory.

Six inches from the rotameter in the feed line is an anhydrous ammonia pressure gage which shows the pressure in the tank.

The rotameter was mounted in a 1½-in piece of pipe about 6 in long. A ½-in rod offset was welded into the bottom of the pipe so that it rested on the tractor housing. This rod takes the weight off the straps which fasten the rotameter to the steering column. By carrying the weight on the rod, the rotameter is kept plumb. A heavy ½x2-in strap is offset and welded to one side of the top of the pipe and extends to the top of the square surface of the rotameter. A U clamp welded to a ⅜x1x4-in bar fastens around the top of the meter. The latter bar is studded to the ½x2-in bar on the side of the meter. The meter can be dismounted by loosening the two studs. The two clamps that hold the rotameter mounting to the steering column are bar clamps that may be slipped on the steering column to plumb the meter. The upper clamp is hinged so that it comes under the throttle lever. The lower clamp fastens around the pipe and the steering column in a horizontal position. It is important that the meter be plumb with the tractor in order not to impair its efficiency.

A ⅜-in No. 346 Hoke bar stock control valve is located 3 in from the rotameter on the down side. Screwed into the valve is a ⅜-in nipple, 2 in long, which is connected to the distribution line. Leading from the valve to the first manifold is a ¼-in 150-lb-test rubber air hose. The manifold consists of two 6-in nipples with a ¼-in hole drilled in the center of one and with the second nipple welded on to the first to form a T-shaped manifold. On the outlet ends of the manifold are screwed ¼-in anhydrous ammonia flanges. These flanges are threaded to take the orifices. The flange caps were turned out on the lathe to a depth of ¼ in to provide a tight fit. The orifices may be removed for cleaning. From the first manifold two lines of ¼-in air hose lead to the applicators for two-row equipment or to two more manifolds of the same design for four-row equipment. These distribution lines are connected with ¼-in galvanized ground pipe unions to a ¼-in pipe or hose on the back of the applicator.

Fig. 5 This picture shows a practical farm setup for an anhydrous ammonia application

When the first applicator was developed, the pipe was welded solid to the shank, which conducted heat so that the expanding ammonia caused freezing of water and soil to the applicator shank. The accumulation of ice and soil on the applicator shank increases its size and prevents shedding of the soil. The applicator shank was made of a ½x2-in steel bar. It was of the chisel type with an oval point that makes a 15-deg angle with the horizontal when set properly. Welded onto the bottom of the knife point was a ¼x4-in pipe in which a bird mouth opening was cut to release the ammonia 4 in back of the point. The pipe down the back of the applicator shank was welded onto the pipe at the bottom to complete the applicator and distribution lines.

The second type applicator shank was built from a ½x2-in steel bar. In constructing this shank, the width was cut down ¼ in in the middle and cut off at a 30-deg angle at the bottom. The shank was then curved and drawn out to a knife edge at the front with a ½x¾-in point drawn out at the bottom. Onto the back of the shank was spot welded a ¼-in pipe. The pipe was cut at a 35-deg angle with the ground and was 1½ in shorter than the shank. The vertical height of these shanks is 19 in.

The third type of applicator was a sword knife with a ¼-in pipe spot welded on the top. The ammonia was released 4 in from the rear and through a ⅛-in hole drilled through the knife and pipe. The bottom of the hole in the knife was welded up so the ammonia was released through two small holes 1 in up from the bottom on each side.

The fourth type applicator was a trip foot which has a ¼-in air hose clamped in a short piece of pipe that was welded to the shank 1 in from the bottom. The trip, which was from a Model A Farmall cultivator, was fastened to a standard from a Model H Farmall cultivator. The bottom linkage was made to extend forward 1½ in in order that a John Deere beet and bean chisel-type foot could be welded in to form the applicator shank. The point of this shank was ground down on the sides to a width of ½ in. The length of the shank was 11½ in when set at a 15-deg angle with the horizontal.

Twelve-inch J. I. Case disk hillers were used to seal the ammonia in soils which were not friable. Because of the four different adjustments provided these disk hillers can be regulated to meet the various field conditions. On friable soils the ammonia was sealed without the use of a covering device.

Metering Methods. There are several known methods of metering liquids which may be applied to liquid anhydrous ammonia, but for experimental work a high degree of accuracy in metering and calibration is desirable.

A variable-control orifice requires innumerable calibrations to take care of the variables such as speed, pressure change, and back pressure, which affect the rate per acre. The same is true with a system of orifices and a differential-pressure regulator or with a metering pump. The vision flow type of rotameter was selected for metering anhydrous ammonia because the rate per acre is affected only by the speed of the tractor. The rotameter permits the operator to change the rate at will after the speed of the tractor has been established. Two makes of rotameters have been used. The first one used was a ⅜-in No. 3 Schutte and Koerting with a maximum delivery of 225 lb of anhydrous ammonia per hour, divided into 5-lb intervals. This meter was used the first year. Since then a ⅜-in 225 lb per hr Fischer and Porter rotameter, divided into 2-lb-per-hr intervals, has been used.

To obtain the correct reading in pounds per hour on the rotameter, the speed of the tractor is first determined for each test. The average speed in feet per second is taken for the total distance for the test. Knowing the average speed in feet per second when the applicator shanks and disk hillers are

running at the proper depth, the calculation for rate is very simple. For instance, the rate of nitrogen is to be 32 lb per acre. Then the average speed of the tractor in feet per second times the number of seconds per hour, times the width of cut in feet, divided by the square feet per acre, multiplied by 39 (the pounds of anhydrous ammonia equivalent to 32 lb of nitrogen) gives the rate of ammonia in pounds per hour. The reading on the rotameter is maintained by regulating the control valve.

From the standpoint of the farm user, a variable-length-stroke metering pump appears to have an advantage over the rotameter. The pump would be timed with the ground speed of the tractor.

Applicators. In developing an applicator there are several factors that should be considered, as follows: (1) anhydrous ammonia must be released under the soil and covered simultaneously; (2) the applicator shanks should shed trash freely; (3) the soil should flow smoothly around the applicator; (4) the applicator should have a fairly short point so that it may be guided easily through the soil without twisting in the holder; (5) soil and water should not freeze to the applicator; (6) it should be of a trip foot type. With these factors in mind the fourth type applicator shank was designed.

From the preliminary test in moist, sticky soil, this applicator shank seems to meet the requirements set forth above. Therefore, this type of applicator shank will be used in the future to replace the long-breakpin, small-point applicator with the pipe spot-welded down the back.

Sealing Anhydrous Ammonia in the Soil. In loose, friable soil, free of trash, no covers are necessary when the applicators are running 5 in deep. During the first year's work a 4-in sweep was used to seal the ammonia under the soil. The sweep worked very well in all friable soils where there was little trash, but it was found that a disk hiller would do a better job on all soil types and trashy conditions. Therefore, 12-in J. I. Case disk hillers have been used for the last two years with success, except for top-dressing oats. For this job the rear wheels of the tractor were set in to split the distance between the applicators and press the soil together. This was possible because a split row setup was used with the applicators set 14 to 15 in apart. It is very easy to tell if ammonia is being lost by smelling the furrow where the applicator shank has run.

Operating the Machine. Bubbling of gas in the rotameter sometimes occurs on cool mornings, which necessitates cooling the lines and meter. To cool the line and meter, the control valve is opened. Then the tank valve is partially opened, allowing the ammonia to evaporate in the line and meter until frost forms on the outside. The control valve is then closed and the tank valve is completely opened. The line and the rotameter have been painted gray to reflect the sun rays. The painting helps, but does not completely eliminate the need for occasional cooling.

Ten-foot alleys are provided between sections of the tests so that the machine can be stopped and started with the meter reading the correct amount each time. With a driver operating the tractor and a second man operating the control valve the correct amount of ammonia is assured at all times. The tractor driver stops at the end of each plot and waits until the control valve operator has stabilized the rotor in the rotameter at the correct reading with all applicators feeding. The next plot is then put out. After the tractor has been calibrated, the speed is not changed throughout the test except in the case of two depths for which separate calibrations are made.

All tests on corn and cotton for the past two years have been paired treatments between anhydrous ammonia and ammonium nitrate. The anhydrous ammonia was applied at the rates of 32 and 64 lb of nitrogen at 4 and 6-in depths. The ammonium nitrate was applied on the surface and plowed in, at a depth of 4 in as a side dressing and at the 4-in depth for preplanting application at a rate of 32 lb of nitrogen per acre.

Where the preplanting application of anhydrous ammonia was made before the ground was listed, a small list was thrown up with the disk hiller in order that the ammonia might be covered at the 4-in depth. Even though a small list was made, it was found that the disk hiller had to be set close to the applicator to get sealing when working in heavy soils, such as Sharkey and Houston clays. Also in side-dressing in these types of soil, when dry, the covers had to be set close to the applicator for the 4-in depth. There was no difficulty found in covering at the 6-in depth. The higher the rate in any soil, the more difficult it is to get complete sealing of ammonia with shallow depths of application.

The test plots have been located on the major soil types of Mississippi. Judging from crop response, sealing of the anhydrous ammonia has been satisfactory on all soil types tested. The efficiency of nitrogen as anhydrous ammonia has proven to be equal to that of ammonium nitrate for row crops.

For oats, judging from crop response, sealing of ammonia with our technique has been satisfactory. The efficiency of nitrogen as anhydrous ammonia has been inferior to, equal to, and superior to that of ammonium nitrate for oats, depending upon time of application and chemical characteristics of the soil. There are difficulties in sealing anhydrous ammonia in the soil where applied as a top-dressing to small grains.

Practical Farm Setup. Most of our work has been devoted to developing a machine to test the efficiency of anhydrous ammonia as a source of nitrogen. Thus, little time has been given to the development of a more practical farm machine.

Practical applicators for putting the anhydrous ammonia in the ground have been worked out and an integral trailer has been constructed which can be mounted on the back of a Model H Farmall tractor in place of the rear gang of the cultivator. The tank mounted on this trailer has a capacity of 600 lb of ammonia. This amount will fertilize 12 acres at 40 lb of nitrogen per acre. The wheel at the back of the trailer casts so that it does not affect the operation of the tractor in any way. This past summer the trailer and equipment were used to apply anhydrous ammonia satisfactorily to 16 acres. With this type of tank mounting all of the safety features can be built into the tank that are necessary for handling anhydrous ammonia.

The major consideration in our future machinery development program will be for a more practical farm machine. Some problems being considered include (1) other methods of metering, such as low cost metering pumps and differential pressure valves and orifices, (2) improved methods of sealing ammonia in the soil in top-dressing small grain, and (3) adaptation of tank and mountings used on the flame cultivator for use with anhydrous ammonia.

Mechanical Tree Planter

(Continued from page 390)

Farmers previously committed to plant from three to five thousand trees per year over a 10-yr period by hand have completed the job in one year by machine. The extension forestry office has records of increasing numbers of absentee owners who contracted for custom-planting service, after which they place the planted lands under the Wisconsin Forest Crop Law. Hand planting had discouraged these owners in the past because it involved the employment of rather large crews over whom lax supervision could result in high planting costs and low survival. Idle lands suitable for machine planting are being purchased by both resident and absentee owners for reforestation as an investment.

Shelter belt planting is readily accomplished by tree-planting machines. A mile long shelter belt consisting of three rows of trees can be completed in a little over one hour.

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Corn and Grain Conditioning With or Without Heat

By Leo E. Holman and Deane G. Carter
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HIGH-MOISTURE corn occurs every year in some localities. The likelihood of immature corn due to late planting, such as in 1947, stimulates the demand for practical information on drying or otherwise conditioning the crop. Occasionally the major part of the crop is too wet for safe storage or profitable marketing at harvest. For example, data from the Inspector's Report to the Grain Branch, Production and Marketing Administration, USDA, covering the 1945 crop shows that out of more than 48,000 carloads of corn received at Chicago from October, 1945, to September, 1946, only 8 per cent graded No. 1, while 23 per cent was No. 5, and 21 per cent was sample grade. This means that 44 per cent (or nearly one-half) of the receipts were in the lower market grades, largely as the result of high moisture.

Experiments at the Illinois Agricultural Experiment Station date back to the early 1920's and cover studies on handling and feeding wet corn, making silage, drying seed corn, and storing, conditioning, and handling soybeans, corn, and wheat. Most of the work has been cooperative between the Illinois station and the Bureau of Plant Industry, Soils and Agricultural Engineering.

Much of the farmer's interest is based on a desire to find a way to safeguard his corn and soybean crops on the farm irrespective of season. The stimulation is based on many factors such as the success with hay finishing, increased availability of equipment, general trends toward mechanization, especially the corn picker-sheller, the practice of commercial drying, and the desire to harvest corn relatively early in the season when conditions are generally favorable.

This interest in conditioning is evidenced by the many and varied questions that are raised. They range from the general question of "How can I make plans for drying the entire crop on my farm?" to details of fan size, duct systems, power, capacity, and cost. Manufacturers and distributors will be interested to note the following specific questions that are continually raised: "Is equipment available now?" "What is the cost?" "What is the best system to use?" "Can equipment be used interchangeably for hay, soybeans, ear corn, and shelled corn?" "Should heat be used, or forced air only?" "What size and type of fan should be used?" "What capacity should be provided?" "How much drying is required?" "How can I determine the proper drying conditions?"

Some of the foregoing questions can be answered definitely as the result of research; other answers depend on further study and practical trials on farms. It seems certain, however, that interest in conditioning goes far beyond the 1947 crop, and that there will be an increasing demand for assistance in defining requirements and planning installations.

Although the current situation may be regarded as somewhat of an emergency, there is already enough evidence available to establish the practicability of conditioning corn and grain as a common practice, and to furnish a guide to designers and manufacturers for the development of equipment. We know, for example, that safe storage requires that kernel moisture in ear corn be brought down to 20 per cent or less; and small grain and shelled corn should be under 13 per cent.

The relationship between relative humidity and temperature is well established. It remains only to provide the farmer with usable data, as, for example, tables on relative humidity values for heated air, which illustrates the reason for heating the air and how much heat to apply for economical drying. A low-cost, simple device for determining temperature and humidity is now available.

The wide scope of the problem of conditioning corn demands the fullest possible cooperation in research and development. This paper is based on the cooperative study carried on by the Illinois station and the U. S. Department of Agriculture, which is also a part of regional cooperation.

The specific purpose of this paper is to report on one phase of the whole problem, namely, recent experiments in drying with and without heat, under various conditions. From among the many phases of work under way, only those experiments are reported that bear on the immediate problem of moisture reduction in ear corn, shelled corn, and soybeans,

This paper was presented at the Conference on Conditioning the 1947 Corn Crop, at Chicago, Ill., July 21, 1947. It presents results from cooperative studies for the Illinois Agricultural Experiment Station and the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

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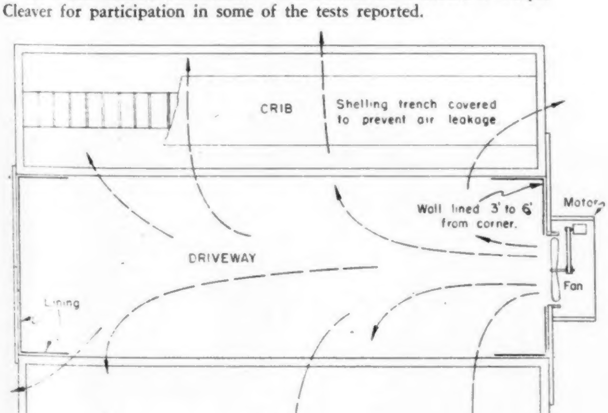
AUTHORS' ACKNOWLEDGMENT: The authors are indebted to Thayer Cleaver for participation in some of the tests reported.



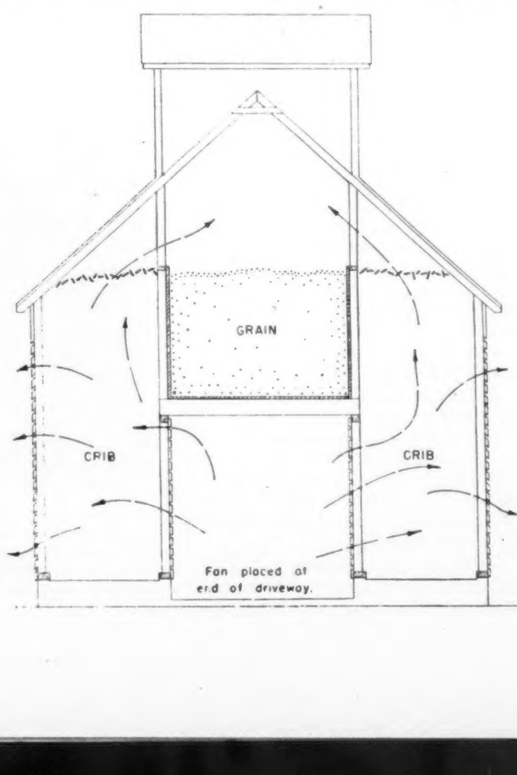


Fig. 1 *(Above)* Plan of double crib with fan at end of driveway. Several points require sealing to insure even flow of air through corn • Fig. 2 *(Right)* Double crib with overhead grain bins

TABLE 1. CRIB DRIER
Plenum Chamber – Driveway of Double Crib
Unheated Air

	Crib 1	Crib 2
Corn Into Crib	5,000 bu (vol)	4,000 bu (vol)
Crib Width	10 ft	8 ft
Moisture Content		
Before drying (wet basis)	23% (cobs 40%)	23%
After drying (wet basis)	20% (cobs 31%)	19%
Drying Time	65 hr	60 hr
Air Per Sq Ft of Plenum Chamber	30-35 cfm	35-40 cfm
Air Temperatures (Avg)	60 F (53-75)	55 F (40-65)
Relative Humidity (Avg)	55% (28-70)	60% (45-70)
Water Removed From Kernels		
Total	10-11,000 lb	10-11,000 lb
Per hour	150-170 lb	170-180 lb
Moisture Reduction	3%	4%
Power Cost Per 100 Bu Per 1% Reduction	4¢	4¢

where results were obtained comparable with shelled corn.

Crib Drying of Ear Corn. During the past two years it has been possible to work with farmers who have used various methods of adapting their cribs for mechanical ventilation, and data have been obtained to show its effectiveness. The principal method reported here is to use the central driveway of the double crib as a plenum chamber. Tests include both heated and unheated air blown into the driveway and forced out through the corn in one or both cribs. Both ends of the driveway are sealed and the fan installed at one end (Fig. 1).

Adapting a crib in this manner is simple and economical; driveway doors, shelling trench, and corners are sealed to prevent air leakage and to insure more even flow of air through the corn.

Where cribs have overhead bins (Fig. 2), the depth of ear corn above the level of the bin floor should be at least as great as the width of each crib; otherwise some "short circuiting" of air may result. Lining of reinforced paper should be provided in double cribs having no overhead bins to insure satisfactory circulation through the corn.

Tests were made in three double cribs with overhead bins similar to that shown in Fig. 3 and equipped as shown in Figs. 4, 5, and 6. In two tests unheated air was used; in the third test, the air temperature was raised about 8 F.

Results of drying with unheated air are summarized in Table 1. Crib 1 was 40 ft long, each crib 10 ft wide, and the driveway approximately 10 ft high. The equipment consisted of a 42-in propeller type fan operated by a 5-hp electric motor. From ratings furnished by the manufacturer, it was estimated that the fan delivered from 30 to 35 cfm for each square foot of inside crib wall surface.

Crib 2 was 40 ft long, each crib was 8 ft wide, and the driveway was 12 ft high. The equipment included a 48-in propeller-type fan operated by a 5-hp electric motor. It was estimated that the fan delivered from 35 to 40 cfm per square foot of inside crib wall surface.

The moisture content before drying was approximately the same in both tests, about the same drying time

TABLE 2. CRIB DRIER
Plenum Chamber – Driveway of Double Crib
Heated Air

Corn Into Crib	5,200 bu (vol)
Crib Width	10 ft
Moisture Content	
Before drying (wet basis)	26% (cobs 47%)
After drying (wet basis)	23%
Drying Time	57 hr
Fuel Consumed Per 100 Bu Per 1% Reduction	
Kerosene	0.5 gal
Gasoline	0.5 gal
Air Per Sq Ft of Plenum Chamber	50-55 cfm
Air Temperature (Avg)	
Plenum chamber	68 F
Outside air	60 F
	8 F
Relative Humidity	
Outside air	72 %
Plenum chamber	57 %
	15 %
Water Removed From Kernels	
Total	11-11,500 lb
Per hour	190-200 lb
Per gallon of fuel (kerosene & gasoline)	72-76 lb
Moisture Reduction	3%
Fuel and Power Cost Per 100 Bu Per 1% Reduction	15¢

was required, and power costs (about 4c per 100 bu per 1 per cent reduction) were similar. Atmospheric conditions were somewhat more favorable for Crib 1 with air temperatures averaging 5 F higher and relative humidities 5 per cent lower. Drying rates appeared to be slightly greater in Crib 2, probably because of the greater volume of air delivered and the narrower width of cribs (Table 1).

Crib 3 was 40 ft long, the cribs were 10 ft wide, and the driveway 8 ft high. A 48-in propeller fan was used, which

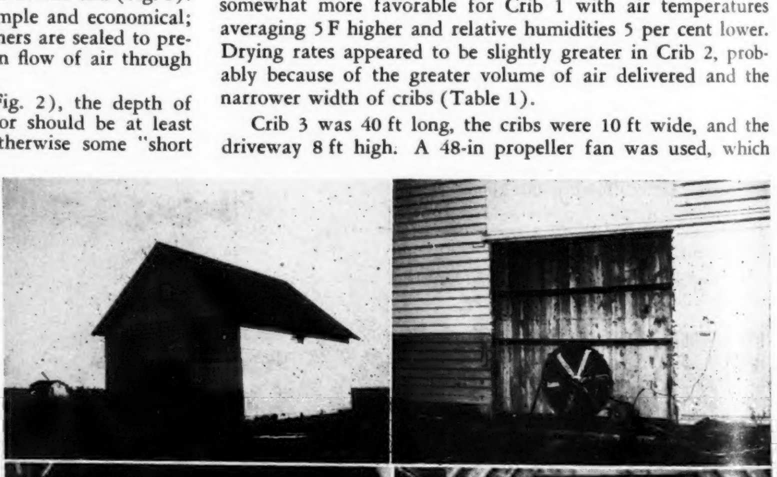


Fig. 3 *(Upper left)* Double crib with overhead bins. Both ends of the driveway have been sealed up and a fan installed in one end for drying the cribbed corn • Fig. 4 *(Upper right)* Closeup view of six-bladed propeller-type fan and 5-hp electric motor • Fig. 5 *(Lower left)* View of fan installation from inside of driveway. Reinforced paper was used to seal up the end and along the walls for a distance of 6 ft • Fig. 6 *(Lower right)* Opposite end of crib showing reinforced paper in place

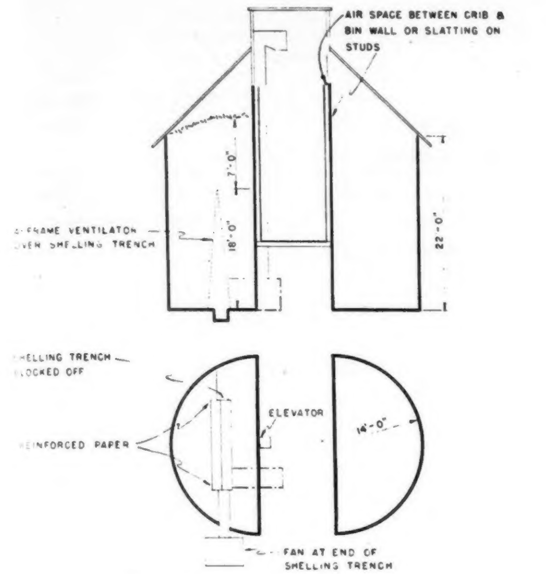


Fig. 7 A curved-wall concrete crib

was operated by a gasoline engine from a grain combine. It was estimated that the fan delivered 50 to 55 cfm per square foot of crib wall area.

In this test the air was heated. Heat was supplied by a weed-burner which used about 1⅓ gal of kerosene per hour. The gasoline engine was enclosed so the exhaust heat could also be utilized. In this manner the temperature of the delivered air was raised about 8F. Table 2 summarizes the results of this test where the drying rate was somewhat greater than in Crib 1 and 2, but the cost was increased by the gasoline and kerosene required. Atmospheric conditions were also less favorable during the time the crib was being dried. Better results would have been obtained by using less air with the small amount of heat available.

In Crib 4 another method was tested where an A-frame ventilator served as a plenum chamber to distribute air through the cribbed corn. The crib is a curved-wall, concrete, double crib with overhead bins (Fig. 7). Each crib has a radius of 14 ft. It was equipped with an A-frame ventilator (30 in wide, 12 ft long, and 18 ft high) set over the shelling trench. Equipment used was a centrifugal-type, forward-curve, double-inlet fan driven by a 3-hp electric motor. It is estimated that

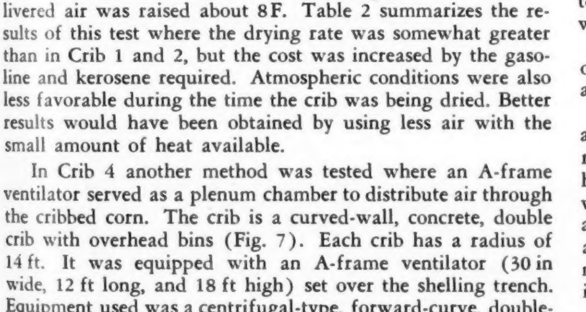
TABLE 3. CRIB DRIER
A-Frame Ventilator – Heated Air

Corn Into Crib	2,500 bu (vol)
Moisture Content	
Before drying (wet basis)	27% (cobs 35%)
After drying (wet basis)	15%
Drying Time	
Heated air	212 hr
Kerosene Consumed Per 100 Bu Per 1% Reduction	2 gal
Air Per Sq Ft of Plenum Chamber	13 cfm
Static Pressure in Plenum Chamber	0.35 in H_2O
Temperatures (Avg)	
Plenum chamber – 136 hr	90 F
76 hr	130 F
Outside air	40 F (11–66)
Relative Humidity (Avg)	
Plenum chamber – 136 hr	15%
76 hr	8%
Outside air	87% (55–96)
Water Removed	
Total	27,600 lb (13.8 tons)
Per hour	130 lb
Per gallon of kerosene	49 lb
Moisture Reduction	12%
Cost Per 100 Bu Per 1% Reduction	
Kerosene	23.6 ¢
Electricity	3.0 ¢

the fan delivered about 6,000 cfm against a static pressure of 0.35 in of water; however, data supplied by the manufacturer indicated that the fan was capable of delivering 10,000 cfm if driven at a higher speed. The air delivery was calculated to be 13 cfm per square foot of plenum chamber wall. (This was below the recommended minimum of air movement.)

Unheated air was blown through the crib for a number of hours before the start of the test but heat was applied for a total of 212 hr. Weed burners were used to supply heat.

Table 3 summarizes the results of the test after heat was applied. During the first 136 hr, the air temperature was raised an average of nearly 50F; during the last 76 hr more heating units were added to raise the temperature by 90F. It would have been more desirable to increase the air volume and hold the temperature increase to not more than 50F. With a 50-deg rise the relative humidity of the delivered air was maintained at about 15 per cent, which is low enough for satisfactory drying. Corn in contact with air at 15 per cent rela-



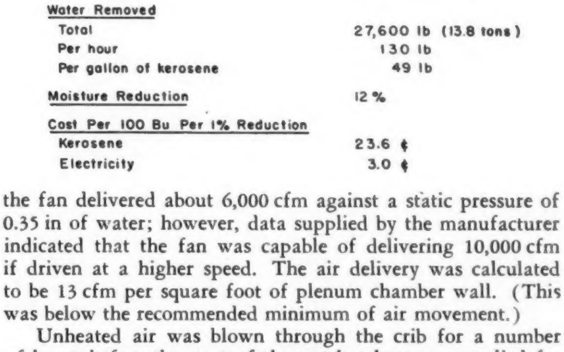


Fig. 8 *(Left)* Soybean drying with unheated air. The fan, controlled by a humidistat, operated only when the relative humidity was below 70 per cent. No drying resulted from 250 hr of operation during November to March • Fig. 9 *(Above)* The variation in moisture content from bin floor to grain surface was much greater in Test 1 than in Test 2. The temperature rise averaged 92 F in Test 1 as compared to 60 F in Test 2. The volume of air was increased 26 per cent in Test 2

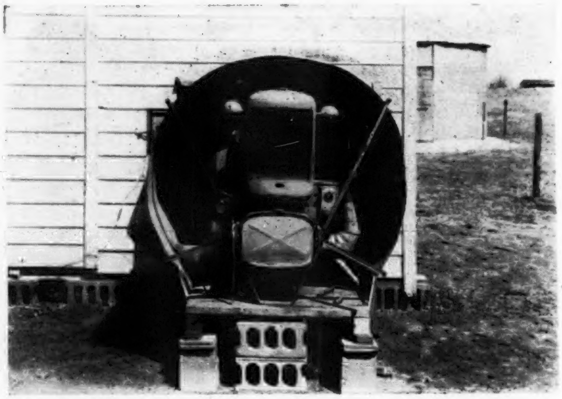


Fig. 10 Portable drying unit. An 8-blade, 36-in propeller-type fan connected to the driveshaft of a gasoline engine. A canopy over the engine is provided to make sure that all delivered air passes over the engine

tive humidity will eventually go down to 10 per cent moisture or less.

The water removed per gallon of fuel was less than in the preceding test, and the cost was higher, yet the total fuel and power cost was only 26.6c per 100 bu for each per cent moisture removed. This figures to 3.2c per bu for removing 12 per cent moisture from the kernels and any moisture taken from the cobs. This compares favorably with commercial drying costs. Moreover, it indicates that good drying can be done even under unfavorable conditions, and with improvised equipment.

Shelled Corn and Small Grains. Most shelled corn and small grain drying has been done in commercial driers. To meet the demand, however, several tests of farm-type driers have been made at the University of Illinois, both with heated and unheated air.

Unheated Air. Several tests have been made with soybeans. The bin was fitted with a perforated floor; the apparatus consisted of a centrifugal fan operated by a ½-hp-electric motor. The fan was controlled by a humidistat.

Results of three tests are summarized in Table 4. In Tests 1 and 2 about 5.5 lb of water were evaporated per hour at a power cost of 8c per 100 bu for each one per cent moisture reduction. In Test 3 about 2.6 lb were evaporated per hour at a power cost of 21c per 100 bu for each per cent reduction. The depth of grain, the volume of air, and the static pressure were about the same in the three tests. The hourly drying rate was nearly twice as great in Tests 1 and 3 as in Test 2, due mainly to the difference in atmospheric conditions. In Test 2 there was no drying from November to March although the fan operated 250 hr when the relative humidity of the air was below 70 per cent. (Fig. 8.)

TABLE 4. BIN DRIER
Unheated Air — Perforated Floor
S. P. – 0.5 in H_2O; Air Vol – 18 cfm per Sq Ft

	Test 1 Aug-Oct	Test 2 Nov-Apr	Test 3 Jun-Jul
Soybeans Into Bin	585 bu	550 bu	535 bu
Moisture Content			
Before drying (wet basis)	14.7 %	13.8 %	14.2 %
After drying (wet basis)	10.7 %	10.5 %	11.7 %
Drying Time	308 hr	494 hr	180 hr
Air Temperatures (Avg)	70 F	44 F	72 F
Relative Humidities (Avg)	60 %	60 %	60 %
Water Removed			
Total	1,600 lb	1,300 lb	990 lb
Per hour	5.5 lb	2.6 lb	5.5 lb
Per kw-hr	17 lb	6.5 lb	17.5 lb
Moisture Reduction	4.0 %	3.3 %	2.5 %
Power Cost Per 100 Bu Per 1% Reduction	8 ¢	21 ¢	8 ¢

TABLE 5. BIN DRIER
Heated Air – Perforated Floor
Grain Depth – 6 Feet

	Test 1. – Feb	Test 2. – Apr
Corn Into Bin	806 bu	780 bu
Moisture Content		
Before drying (wet basis)	19.5 %	18.5 %
After drying (wet basis)	11.8 %	9.0 %
Drying Time	50 hr	40 hr
Fuel Consumed Per 100 Bu Per 1% Reduction		
Kerosene (burner)	1.8 gal	1.4 gal
Gasoline (fan engine)	0.3 gal	0.4 gal
Air Per Sq Ft of Floor	26 cfm	32 cfm
Static Pressure in Plenum Chamber	1.3 in H_2O	2.4 in H_2O
Temperatures (Avg)		
Plenum chamber	126 F	105 F
Outside air	34 F	45 F
	92 F	60 F
Relative Humidity (Avg)		
Plenum chamber	7 %	9 %
Outside air	70 %	65 %
Grain Surface	90 – 95 %	80 %
Water Removed		
Per hour	64 lb	105 lb
Per gallon of kerosene (burner)	34 lb	47 lb
Per gallon of gasoline (engine)	180 lb	157 lb
Moisture Reduction	7.7 %	9.5 %

Heated Air. Two drying tests were made with shelled corn in a bin equipped with a perforated floor. A weed-burner supplied supplementary heat.

A summary is given in Table 5 of the results of the two tests. In Test 1, moistures were reduced 7.7 per cent in 50 hr; in Test 2, 9.5 per cent in 40 hr. The total fuel consumption (gasoline and kerosene) per 100 bu for each per cent moisture reduction was 2.1 gal in Test 1 and 1.8 gal in Test 2.

The results show that, as compared to Test 1, Test 2 gave the following: (1) about 23 per cent greater air delivery, (2) less fuel consumption by the burner, but more gasoline for operating the fan, (3) the total kerosene and gasoline per each per cent moisture reduction was slightly less, (4) the drying rates were 64 per cent higher, and (5) the moisture gradient through the grain was much less. (Fig. 9.)

During the first test the relative humidity of the air at the grain surface remained near saturation during the entire test; in the second test the average was about 80 per cent.

In a number of shelled corn and soybean drying tests the heat given off by a gasoline engine was the only heat added. A canopy was constructed over the engine to bring incoming air past the engine. Extra exhaust piping was added which reduced the temperature of exhaust gases to 200-250F at the outlet end. (Fig. 10.)

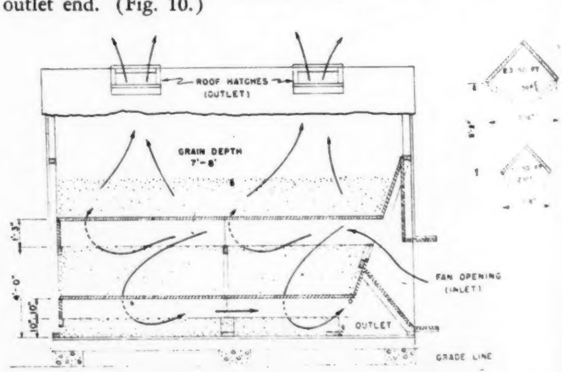


Fig. 11 Plywood bin equipped for mechanical ventilation of grain (size, 16x16x8 ft; capacity, 1200 bu at 7-ft depth)

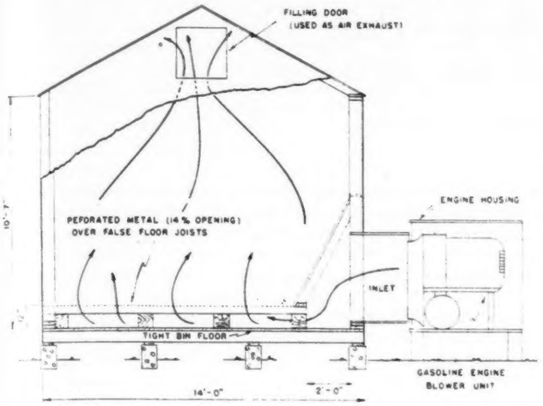


Fig. 12 Bin equipped with perforated floor for mechanical ventilation of grain (size, 8x14x9 ft)

Two methods of circulation were used. One bin was equipped with ducts as shown in Fig. 11. With this system the upper set of ducts brings air through the center of the mass of grain; about one-half of the air moves to the surface and the other half goes down and is exhausted through the lower ducts. Thus with a grain depth of 7½ to 8 ft it is necessary to move air through only about 4 ft of grain.

The second bin was equipped with a perforated floor having 14 per cent openings as shown in Fig. 12. In this system, air is forced upward through the perforated floor and entire depth of grain.

Tests were run simultaneously in the two bins using two portable engine-operated fans. The unit on the duct system was not operated as long as the other one due to mechanical troubles.

Table 6 summarizes the results of the tests with the two systems. In the duct system the moisture content was reduced 6.1 per cent in 1,320 bu in about 91 hr. In the perforated floor system the moistures were reduced 7.9 per cent in 682 bu in 117 hr. The fuel costs per bushel for each per cent moisture reduction were about 0.2c in the duct system and 0.45c in the perforated system.

About one-half as much gasoline was required per bushel per per cent moisture reduction with the ducts as with the perforated floor. The air delivery per square foot of floor or of plenum chamber was about the same in each case. However, the *total volume* of air delivered was three to four times as much with the ducts as with the perforated floor.

The efficiency of the fans used in these tests falls off at the higher pressures. Therefore, if a static pressure of about 2.0 in of water, instead of 3.4 in, had been maintained in the perforated floor system, the efficiency of the two systems would have been more nearly equal.

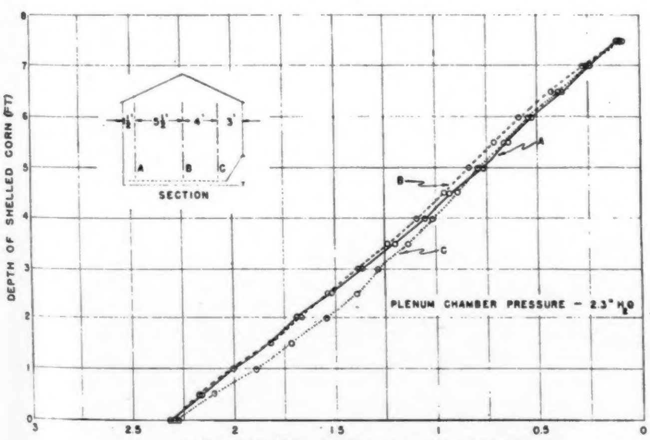
Air movement through the grain was quite uniform in different sections of the bins as was evidenced by static pressure readings taken at various locations throughout the bin. (Fig. 13.)

Comparative drying rates at various levels in the bin are shown in Fig. 14. The rate of drying was similar near the floor and upper surface with the duct system; it was considerably faster near the bin center where the air entered the bin. Drying was rapid near the perforated floor but much slower at the 7½-ft level near the upper surface.

Continuous Drying. Tests have just been completed using a continuous drier for conditioning soybeans. With this system, the grain is heated as it passes *(Continued on page 408)*

TABLE 6. BIN DRIERS – SHELLED CORN
Heat From Gasoline Engine
Grain Depth – 7½ Feet

	Duct System	Perforated Floor
Corn Into Bin	1,320 bu	682 bu
Moisture Content		
Before drying (wet basis)	20.3 %	20.3 %
After drying (wet basis)	14.2 %	12.4 %
Drying Time	90.9 hr	116.9 hr
Gasoline Consumed Per 100 Bu Per 1 % Reduction	1.3 gal	2.4 gal
Air Per Sq Ft	26 cfm	27 cfm
Static Pressure in Plenum Chamber	2.0 in H_2O	2.3 – 3.4 in H_2O
Temperatures (Avg)		
Plenum chamber	53 F	63 F
Outside air	43 F	43 F
	10 F	20 F
Relative Humidity (Avg)		
Outside air	65 %	65 %
Plenum chamber	43 %	32 %
	22 %	33 %
Water Removed		
Per hour	59 lb	32 lb
Per gallon of gasoline	49 lb	28 lb
Moisture Reduction	6.1 %	7.9 %



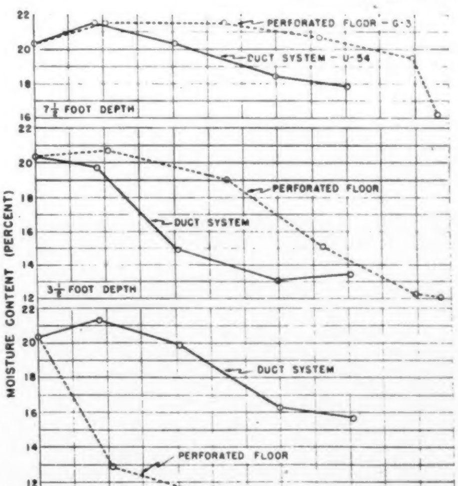


Fig. 13 *(Above)* Static pressure readings indicated rather uniform flow of air through the grain. The above readings were made near the fan inlet, at the bin center and near the wall farthest from the fan inlet • Fig. 14 *(Right)* Drying rates of shelled corn perforate d floor and duct systems

Soil Erosion Studies — Part VI

SOIL DETACHMENT BY SURFACE FLOW

By W. D. Ellison and O. T. Ellison
MEMBER A.S.A.E.

FLOWING surface water is the second of the major erosive agents to be discussed. It erodes soil by a process which is best described as scour erosion, while splashing raindrops erode by a splash process. Surface flow detaches and transports soil in downslope directions. In doing this it sets up certain erosion hazards that may prove both troublesome and wasteful of soil if not controlled. These hazards differ from those caused by splashing raindrops, both in respect to their effects on the infiltration of rainwater, and the scars they make on the land.

There are two principal differences in scour and splash erosion that will cause each to affect infiltration differently. One of these differences is in the way that soil aggregates are broken down in detaching. Those detached by splash are broken down into much finer parts than are those detached by the scour process. Another difference is in locations of detachment. Soil detached by the splash process may muddy the surface water over an entire field, and this, along with the soil puddling that the splash causes, has a major effect on impeding the infiltration. Scour erosion is active primarily in channels, and the soil detached by this process remains largely confined to channels as it moves downslope and off the watershed. This prevents it from muddying surface water and thereby checking infiltration over any considerable part of the area.

Another important way that the erosion caused by surface flow varies from that caused by raindrop splash is that scour erosion will usually make rills and gullies, while splash erosion tends to remove sheets of soil from the surface. One of the primary causes for these differences in the actions of raindrops and surface flow are to be found in the distribution of the energy of these two erosive agents. While the energy of splashing raindrops will tend to be uniform on each acre of a sloping surface, from top to bottom of a hill, the energy of surface flow will tend to concentrate and be greatest on the longest slopes; increasing with each increment of slope length that is added. Each unit of slope length that is added to the lower end of a slope course tends to increase the quantity of water that flows off the lower end of the slope, and it also adds a unit of head through which the water must be lowered in the runoff process. Since both the quantity of water flowing and the total height through which the water must fall are functions of the slope length, *L*, we find that the potential energy[1] of the rainfall that will run off the sloping surface is a function of L^2.

A study of these principal differences in the distribution of the raindrops and surface flow will help to explain differences in the erosion patterns they produce on the land. Because its energy tends to be proportional to L^2, the surface flow will tend to produce the largest gullies and cause the greatest soil losses from near the lower ends of the longest slopes. But the energy of the raindrops which erode the soil by splashing is uniform from top to bottom of the slope. This uniformity of the energy factor will tend to produce maximum soil loss at the crest of the slope where the least amount of energy is required to transport the soil. Here the transportation factor consumes very little energy, and much of the energy of the splashing raindrops can be applied to detaching soil. Farther downslope, more energy is required to transport the detached materials because the soil brought down from upslope must also be transported by a process of resplashing. At some critical distance downslope, all the raindrop energy may be consumed in this resplashing of the soil that is splashed down from upslope, and the area downslope from this critical point will not lose soil by the splash process acting alone. Fig. 1 shows a typical pattern of erosion that is largely caused by raindrop splash where the greatest soil loss per unit of area is near the crest of the hill and on the shortest slopes. Fig. 2 shows a typical pattern of soil erosion that is largely caused by flowing surface water; erosion that increases in severity as the slope length is increased.

It will usually be found impossible to make shallow sur-

[1] If E_t is the loss in elevation of the surface water expressed in foot-pounds per hour, when it flows off the lower end of a strip of hillside 1 ft wide and *L* ft in slope length, it may be computed from the equation

$$E_t = \int_0^L e_t \, dL = \frac{62.4}{12} \, \frac{QS}{2} \, L^2$$

Where e_t is the foot-pounds of energy represented by the loss in elevation as the water moves down 1 ft of slope; Q = the runoff in inches per hours; S = the sine of the slope, and L = the length of the slope measured in feet.

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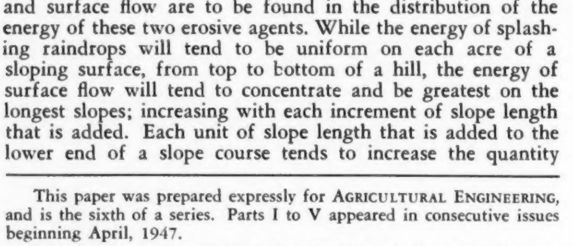

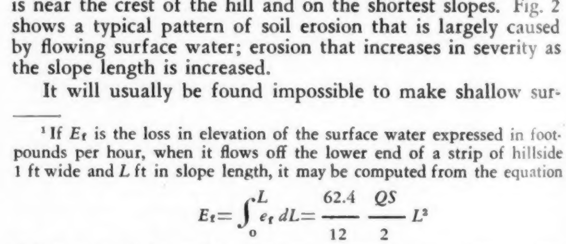

Fig. 1 *(Left)* In this field most of the topsoil is removed from upper reaches of slopes where surface flow is minimum. Farther down the slope there is more topsoil. This is typical of fields where splash erosion is active. Contrast this with Fig. 2 where gully erosion is most active near the base of the slope • Fig. 2 *(Right)* On this soil the gullies increase in size as they approach the bottom of the slope. This could be caused by the flow not being fully charged, and its detaching capacity may then continue to increase as the gully flow moves downslope

face flow, acting alone, detach soil in thin sheets or thin layers from broad surfaces of a field. The effects of irregularities in surface smoothness, together with the effects of other irregularities in the soil's structural properties, will cause the flowing water to form minor rills (channels) just as soon as the scour process becomes active. Once these minor rills are formed, the only significant erosion caused by the flowing surface water will be within these channels.

In this paper we will apply the detachment equation to the scour erosion process which detaches soil materials where concentrated flow occurs, such as in rills and gullies. This equation contains two basically different groups of factors that combine to control the detachment process. These basic groups relate to (1) the soil's detachability and (2) the detaching capacity of the erosive agent.

If the soil is both highly detachable and highly transportable, such that only small amounts of flow will cause it to be detached and transported, small rills may form very close together. Fig. 3 shows a field of such soil in the Palouse country of Washington. In this photograph one finds small rills every few feet, and these channels drain their water and soil loads into several larger rills that extend down the full length of the hillside. This field's soil is highly detachable, and it is higher than average in its transportability. It is considered to be one of our highly *erodible soils.*

It is interesting to note that the three larger gullies in the foreground have cross sections of uniform size from top to bottom of the slope. This indicates that the gully flow did not take on increased amounts of soil as it moved downhill. Since this soil is highly detachable we are reasonably certain that the detachment process did not limit the erosion, and that the flow would have taken on more soil and made the gullies larger near the base of the hill, had it had the transporting capacity to carry more soil. Erosion must have been limited by the transportation process. If it was, then we may assume that the surface water was almost fully charged, from the time the raindrops splashed and became mixed with surface soil until the time of runoff at the base of the slope. We have not usually thought of the shallow flow moving into these gullies being capable of transporting as high percentages of soil as is the gully flow itself. However, if the soil is bare and highly detachable, the splashing raindrops may keep the thin layer of surface water even more highly charged than is the gully flow.

Usually we find that this condition, where the water flowing into the gully contains as much soil as the gully flow can transport, will continue for only a short period at the beginning of the storm. The surface soils will then tend to become compacted and their detachability decreases. When this happens, the water flowing into the gully may be low in soil content and the gully flow may then continue to take up soil until it reaches the very bottom of the slope. Thus we may assume that gullies of the type shown in Fig. 3 may be caused by a storm of short duration, or they may be caused by failure of the soil to consolidate and undergo a decrease in its detachability. We know that this soil is highly detachable and that its detachability does not usually decrease very rapidly.

A soil that is of low detachability will withstand considerable concentrations of surface flow before large amounts of its materials become detached. A soil that is of low transportability will withstand considerable concentrations of flow before the detached particles are transported. Because of this we will find in soils that are of either low detachability, or low transportability, the rills will tend to be considerable distances apart. The erosion patterns we find on these erosion-resistant soils are typified by Figs. 2 and 4. In Fig. 4 only one rill of appreciable size was formed during a heavy rainstorm. We also find in these soils that the rills and gullies will tend to increase in cross section toward the lower edge of the slope (see Fig. 2). Differences in soils at various elevations on a hillside, changes in slope when passing from top to bottom of a hill, and lack of uniformity in other factors may prevent development of gullies of the type shown in Fig. 2. However, if soils are of either low detachability, or of low transportability or both, these factors will tend to make any gullies that are formed have cross sections which increase in size from top to bottom of a hillside.

There are at least three different processes of soil detachment in scour erosion, which may be characterized by the terms *rolling, lifting,* and *abrading*. We will discuss each of these very briefly.

When surface flow moves across a smooth soil surface, there are forces at work that tend to roll or drag soil particles along with the flow. Surface velocities may reach such magnitude that these forces will dislodge particles from their moorings in the soil mass by rolling or dragging them out of position. This process of soil detachment we have characterized by the term *rolling*. The extent of soil particle dislodgments by this process will depend primarily on (1) how well the particles are moored (soil detachability) and (2) the energy of the surface flow.

The soil detachment process we have described by the term *lifting* occurs when water moves upward past soil particles on the surface. A rough surface that contains many small depressions between clods and crumbs of soil, will retain considerable amounts of free water that has no horizontal velocity, while the water just above it will be flowing. This difference in velocities will set up pressure differences between these layers, which will undergo change with each pulsation in the upper layer. These changing pressure differences cause vertical currents and eddies to be set up and the upward flowing water may lift particles of soil materials from their moorings and set them in motion. Here again the amounts of soil materials detached by this process will depend upon (1) the detachability of the soil and (2) the energy of flow.

The soil detachment process described by the term *abrading* occurs when abrasive soil particles in transit dislodge other particles from the surface by a process of abrasion. This

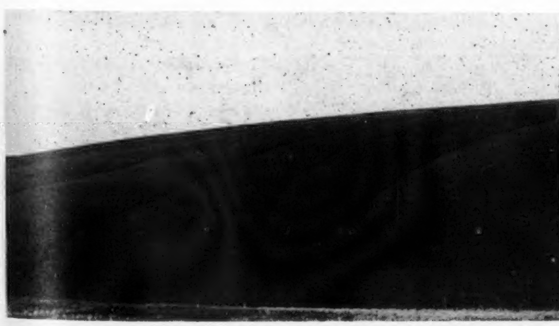

Fig. 3 *(Left)* Many small gullies are developed in this highly detachable soil. A characteristic of these gullies is that they tend to be of about uniform size from top to bottom of slope. This may indicate that the flow is charged to the limit of its transporting capacity, from the very hilltop to the valley bottom, and that the transportation factor limits the erosion • Fig. 4 *(Right)* This field does not have frequent gullies of uniform size, as does the field in Fig. 3. This soil is less detachable, and the single gully shown does not reach to the upper edge of the watershed. We may assume that, as the water moves downslope, its detaching capacity increases, and when soil detachment limits the erosion process, this increased detaching capacity will accelerate the erosion. Strip cropping should prove very effective on this soil. The same applies to Fig. 2 which is a similar problem but with the erosion more advanced

abrasion is caused by soil fractions in motion in the flow being pounded against or dragged along in contact with the surface soils. The amounts that will be abraded will depend upon the factors of (1) soil detachability, (2) energy of the surface flow, (3) amounts of abrasive materials in transport, and (4) abrasive properties of the materials in transport.

Now let us refer to the detachment equation, in order to see how each of the above factors may be accounted for and fitted into it. This equation is written as follows:

$$D'_1=f(D'_2, D'_3) \qquad [1]$$

Where D'_1 = the soil detachment hazard

D'_2 = the soil's detachability

D'_3 = the detaching capacity of the flow.

(Note: The legend D' indicates that we are applying the detachment equation to surface flow. When this equation was applied to raindrops[2] the symbol D was used.)

Soil Detachability, D'_2. A method was presented in a previous paper for determining soil detachability by the splash process[2]. This provided for introducing a standard soil and exposing it to rainfall along with a number of other soils. The amount of the standard soil detached and splashed by raindrops was then divided into the amount splashed on each of the other soils, and these dividends were accepted as relative values of the detachabilities of the other soils. It is probable that these same values of detachability will apply in the scour erosion process. Tentatively, that assumption will be made, because satisfactory methods have not been developed for measuring a soil's detachability by the scour process. However, studies will be continued in an effort to develop techniques for measuring a soil's detachability as it responds to erosive energy applied in the form of surface flow.

Detaching Capacity of Surface Flow, D'_3. The two soil detachment processes described by the terms *rolling* and *lifting*, are largely affected by the soil's detachability and by the energy of surface flow. Detachment by *abrading* is also dependent on soil detachability and energy of the flow, and in addition it depends on the quantities and the abrasive properties of the materials transported by the flow. The detachability of a soil is designated as D'_2 in equation [1], while the factors of energy, quantities and properties of abrasive materials in transport combine to make up the D'_3 factor (the detaching capacity of the surface flow). A summary of the principal factors that affect the D'_3 values follows:

$$D'_3=f[(V^2/2g)\,M\,\beta] \qquad [2]$$

Where,

$V^2/2g$ = the energy gradient of the flow

M = the quantity of abrasive materials per unit of flow

β = a measure of the abrasive properties of the materials in transport.

From a study of the fundamentals of the problem, it seems that the relationship indicated in equation [2] will be of the nature of $D'_3=f(V^2/g)+f(M\beta)$. However, for the present we know too little about the function to do more than use it as shown in equation [2].

Let us now substitute the three factors as shown in equation [2] for the factor of D'_3 in equation [1], and our expression reads:

$$D'_1=f[D'_2(V^2/2g)M\beta] \qquad [3]$$

In some exploratory tests, where clear flowing water would not detach soil on a clay bed, it was found that the detachment process could be made active by injecting abrasive materials into the flow. While these abrasive materials were being injected, the detachment was found to be very sensitive to changes in each of the factors $V^2/2g$, M and β.

The effects that each of the three factors of $V^2/2g$, M, and β will have on soil detachment will depend somewhat upon the value of the D'_2 factor as shown in equation [3]. For each increase in the D'_2 factor, there may be a corresponding reduction in $V^2/2g$, M, or β, without reducing the detachment process. If the soil's D_2 factor is very large, clear water flowing over the surface — containing no abrasive materials — may cause scour erosion. The field shown in Fig. 3 contains such a soil. In many instances, the factor that will limit soil erosion on this land will be restricted transporting capacity. Under these conditions we do not usually expect an increase in the M factor to cause increases in the rates of scour erosion. Actually a reduction in the M factor (the silt load) will usually accelerate rates of erosion on this soil of high detachability, especially so if the surface flow is carrying close to maximum load of soil at the time the silt load is reduced. These increased rates of erosion that occur each time the silt load is reduced tend to explain one reason why strip cropping without terraces will often fail on some of our highly detachable soils. The clear water that flows out the lower edge of the filter strip will have great transporting capacity. Since high detaching capacity is not needed to detach and set these soils in motion, this high transporting capacity insures the "picking up" of a large amount of soil just as soon as the clear water flows out of each filter strip. Terraces are usually needed to support contour strip cropping on these soils. They are needed to intercept the clear water flow as it moves out of a filter strip, and direct it along the contour and off the field.

As we go from soils of very high to soils of very low detachability, we come upon soils that are not detached by clear flowing water, except when flowing at exceedingly high velocities—velocities that are usually in excess of those occurring on cropped fields. On these soils of very low detachability practically all of the soil detachment is by the process of *abrading*. This process will be sensitive to the factor $V^2/2g$, and it will also be sensitive to changes in either the M or the β factors. It will be most sensitive to $V^2/2g$ when the M and β factors are large, and least sensitive when M and β approach zero. Fig. 5 shows contour strip cropping on a soil of fairly low detachability. The clear water that emerges from the lower edge of the filter strip does not detach significant amounts of soil materials.

Contour strip cropping is expected to show at its very best on soils of low detachability, and which have considerable amounts of abrasive soil fractions of transportable sizes. Such a soil may tend to gully badly if the detaching capacity D'_3 is not reduced by removing the abrasive fractions from the flow. This can be done with filter strips. As the flow moves across a strip of open soil, it gathers abrasive materials which will cause it to start cutting small rills. At this point it is made to enter a filter strip where its charge of abrasive materials is removed. The clear water that flows out from the lower edge of the filter strip will not cause detachment until it again becomes charged with abrasive materials which it takes up while flowing across the next strip of open soil.

In these fields where the soil is of low detachability, the filter strip need be only wide enough to remove the abrasive materials from the flow, and a series of narrow, contour buffer strips may prove as effective for these purposes as will much wider strips of close growing crops. An examination of equa-

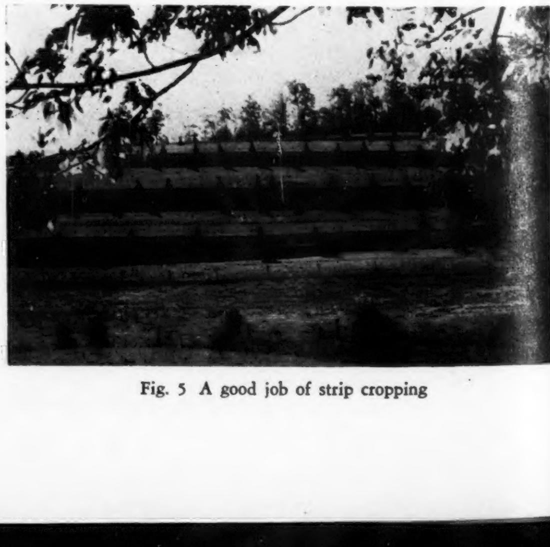

Fig. 5 A good job of strip cropping

[2]Soil Erosion Studies — Part II, Soil Detachment Hazard by Raindrop Splash. AGRICULTURAL ENGINEERING, May, 1947.

Fig. 6 Undoubtedly this soil is of low detachability and the M and β factors were very effective in causing this erosion. Note the rounded bottom of the gully in left foreground

tion [3] will establish the fact that the widths of strips which contain the unprotected soil should be varied with (1) the detachability of the soil, (2) the slope and quantity of water flowing (both of which affect the energy of the flow), (3) the occurrence of abrasive materials in the soils and their transportabilities, as these two factors will help to govern the value of M, and (4) the abrasive characteristics of the eroded materials in transit. Here we have the four principal factors which affect gully formations, and an increase in any one of the four may be cause for gully erosion becoming active.

On soils of low detachability, the occurrence or absence of gullies on a hillside can often be explained on the basis of the M and β factors. Both of these can be affected by soil and storm characteristics, and they can be modified by cropping and tillage practices. If the soil's abrasive fractions are fairly large and of low transportability, or if they are few in number, there may not be enough of these in transport to cut gullies until the flow approaches the base of the hill. But in soils that contain considerable amounts of very fine abrasive sands that are not bound up in stable aggregates, and which are of fairly high transportability, gullies will usually extend to near the hilltops.

Fig. 6 shows gullies with rounded, smooth bottoms. It is evident that these soils are of low detachability, and that the abrasive materials in the flow (the M and β factors) are primarily responsible for most of this cutting. The soil was detached by *abrading*.

The experimental techniques for evaluating each of the three factors that affect D'_3 (on the right of equation [2]), will require that we introduce a standard material with a known, constant D'_2 value, and expose this to the erosive actions of different flows in which each of the factors $V^2/2g$, M, and β are manipulated as independent variables and varied one at a time[3]. It is probable that as many as three different standard materials may be found necessary. One of these may be of high detachability, on which detachment will take place when clear water flows over it, by the processes of *rolling* and *lifting*. A second standard material would probably be of very low detachability, where practically all of the detachment is by *abrading*. A third standard material of medium detachability could represent a soil where *rolling, lifting,* and *abrading* may all be active at the same time.

There are several other requirements for this standard material. One would be that it be highly transportable. This is necessary in order to make certain that the detachment process and not the transportation process limits the rates of erosion. Still another requirement for the standard soil will be that, after it is detached, it not cause a change in the detaching capacity of the flow. This will necessitate that its β factor be approximately equal to that of clear water, or that the material be so light that when detached it will float along on the surface, as would cork, and not cause abrasion.

The factor $V^2/2g$ represents the energy factor in our equation. In shallow flows of not more than several inches deep this energy factor will be affected by the splash of falling raindrops, and as the depth of flow is decreased from several inches to fractions of an inch, the effects of the splashing raindrops will tend to increase. These raindrop effects relate only to the scour process, and they were not accounted for in our splash erosion studies. This makes it necessary that we run two tests for each value of $V^2/2g$, where V is the velocity of translation; one of these to be without waterdrops striking the surface of the flow and the other with waterdrops. Specifications for these drops should be the same as for splash erosion experiments[2]. Results from these two types of tests will show the erosive character of shallow surface flows—first, when they are free of raindrops striking the surface, and, second, when raindrops of near-maximum impact strike the surface of the flow. It is probable that a comprehensive study of the effects of varying drop impacts on the erosive character of surface flow will eventually prove to be a worth-while and even necessary part of this research.

The first work of investigating these various factors was carried on by the senior author at Coshocton, Ohio, about 1939. But that work was only exploratory, and no attempt was made to develop a standard soil which could be used for evaluating each of the different variables comprising the D'_3 factor. More experiments were run in 1942 and 1943, but again the tests were only exploratory, in an attempt to identify the principal factors that affect scour erosion and to develop plans for their study.

In February, 1947, the authors conferred with Dr. J. C. Hide and O. N. Monson of the faculty at Montana State College and solicited their assistance in developing some standard soils for making these tests. A number of suggestions came out of this conference, and since that time the junior author has made enough tests to cause us to believe that Bentonite or some similar material may be used for one of our standard soils.

The authors believe that once these standard materials are developed for evaluating changes in the erosive capacities of different surface flows, the D'_2 values for different soils can then be measured by the scour erosion process. After this is achieved, it should be a fairly simple matter to determine the primary causes for scour erosion on various soils and slopes, and to select the most effective practices for controlling scour erosion on each. Such things as determining where strip cropping and terracing will be most effective, the proper widths of strips and spacing of terraces, permissible variations from true contour operations, and many other features of the erosion control practices will also depend on variations in these four principal factors that effect the scour erosion process.

Impediments to Scour Erosion R'. After we have worked out the relationships of erosive factors and erodible soils, the next step is to evaluate the things which impede or check the erosion processes. These represent the "tools" with which we work to check soil erosion, and they are represented by the symbol R'. They include such things as stems and roots of plants. Plant roots are usually much more effective in checking erosion by the scour process than they are in checking erosion by the splash process. Both the stems and the exposed roots of plants will tend to impede and check the erosive actions of surface flow. It is also believed that the roots may affect the detachability of a soil when erosion is by the scour process. This will change the value of D'_2 that we use in the detachment equation. But the value of R' that we use in this equation will change only when there is a change in conditions of flow that affect the D'_3 factor. They may do this through changing $V^2/2g$, or the value of M. One example of plants reducing the value of D'_3 through reducing M is demonstrated where filter strops remove abrasive materials from the flow. While this flow is moving through a filter strip the factor of $V^2/2g$ may also be reduced. *(Continued on page 408)*

[3]Soil Detachment by Water Erosion. Paper presented at a meeting of the American Geophysical Union, April 28, 1947.

Forced Ventilation for Dairy Barns and Poultry Houses

By Truman E. Hienton and J. R. McCalmont
FELLOW A.S.A.E. MEMBER A.S.A.E.

VENTILATION of dairy barns and poultry houses by using electric fans has commanded increased attention in recent years. Farmers, agricultural research workers, and manufacturers are interested in the further development and evaluation of electrical methods of ventilation in these buildings. The continuing increase in availability of electricity to American farmers (52.9 per cent, July 1, 1946) will make possible general use of these electrical methods if they answer this problem of ventilation.

When air is inhaled by an animal, a part of the oxygen it contains is utilized by the body, and when it is exhaled it is warmer than when taken into the body. It contains a reduced amount of oxygen and an increased amount of moisture and carbon dioxide given off by the body. For the maintenance of the satisfactory condition of 17 parts CO_2 per 10,000 of air in the barn, King[7*] suggested that 3600 cu ft of air per cow per hour be supplied.

Later studies by Ritzman[9] at the New Hampshire Agricultural Experiment Station indicate that the "increase in carbon dioxide approaching one per cent is not injurious or disturbing which is contrary to common opinion." This is important because of King's earlier recommendations which were based on a CO_2 content of about one-sixth this amount.

Factors other than air purity are involved in the ventilation of a dairy barn, principally temperature and relative humidity. Heat required to maintain the stable temperature at a comfortable degree is given off by the animals themselves and is seldom provided by another source. Tests have shown that the quantity of milk yield is decreased by sudden changes in temperature. While this effect is only temporary, when conditions return to normal production will be below the lactation curve (Kelley and Rupel[6]).

Moisture in the air which may condense on walls and ceilings is given off by the animals during respiration as water vapor at the rate of 15 lb or more per animal each 24 hr (at 65F). In addition there is an unknown amount evaporated from mangers, gutters, and washed surfaces in the stable.

The following stable temperatures are considered satisfactory by Miller et al[8] for average conditions in winter in the designated zones (Fig. 1).

Zone	Stable temperature in winter of
1	35 - 45 F
2	40 - 50 F
3	45 - 55 F

Stable temperatures should not fall below freezing even on the coldest days; relative humidities in stables should not exceed 75 per cent under average weather conditions or 85 to 90 per cent on extremely cold days.

Experience has shown that air flow must be controlled at certain times to regulate the temperature of stables and to avoid sudden extreme fluctuations. This need increases with the severity of winter conditions. Present belief as listed by Strahan[10] is "that varying air flow as a means of regulating temperature is to be preferred to maintaining constant air flow in order to regulate air purity, so long as this can be done without causing humidity to rise to the dew point of interior wall surfaces."

The discussion thus far, has been of the need for ventilation in dairy barns. What then is the need, if any, for forced or mechanical ventilation which the gravity system does not meet? One important need which is met by electric ventilation is that air change in the dairy stable can be controlled regardless of inside and outside temperature difference, wind, or height of barn. Another possible need which can be met by electrical ventilation is that of automatic operation.

Installation of electric ventilating equipment is simpler than that of the gravity system in that no outtake flue is constructed up through or at the end of the barn. Fans are being installed near the stable floor and also near the ceiling. In some fan installations, near the ceiling, a duct is built to reach from the fan to within 15 in of the floor. In such cases, air is exhausted from near the floor during the winter. By installing hinged doors at the top and bottom of the duct, air may be taken from near the ceiling when the top door is open and the bottom door is closed. Such an arrangement is desirable for exhausting warm air from the stable during the summer.

A difference of opinion exists on the necessity for providing air intakes for electric fan ventilation. Their installation is recommended by Fairbanks and Goodman[4], also Miller et al, while Bugbee[3] observed that air comes in through natural leaks in such a way that it is quite evenly distributed. His observation is shared by Esmay, based on results of tests during the past two winters under his direction. The final answer to this question may be determined by the construction of each individual barn.

Difference of opinion also exists on the need for the use of control devices. Fairbanks and Goodman do not recommend thermostats for use with fans "(1) because it is impor-

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1946, as a contribution of the Rural Electric Division.

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*Superscript numbers refer to appended references.

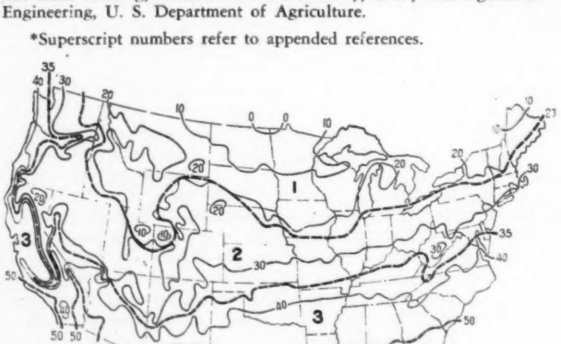

Fig. 1 Average January temperatures in degrees Fahrenheit for the four climatic zones of the United States

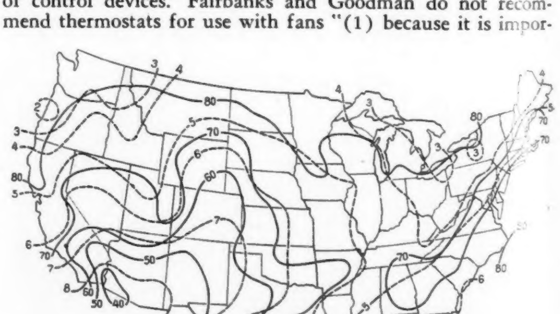

Fig. 2 In this map the broken lines indicate the average number of hours of winter sunshine, and the solid line the mean relative humidity for January

tant to run the fans continuously and (2) if the stable is properly built and well stocked, and if the air is removed from near the floor, there is no occasion to stop the fan because of temperature." Bugbee used a two-speed motor with thermostat control. Esmay is using a humidistat control and air is removed from near the ceiling.

Recommended fan capacities for the ventilation of dairy stables also vary. Fairbanks and Goodman recommend a fan capacity of 60 cfm per head of stock, which is King's recommendation on air change, but suggest that it may be necessary to throttle the inlets during periods of prolonged cold weather. Bugbee also recommends a fan capacity of 60 cfm per cow but provides for reducing this amount through the use of a two-speed motor and four-step pulley. Miller et al recommend a combined capacity of all fans of 70 to 100 cfm per 1,000 lb of livestock. The use of two or more fans or one fan with two or more speeds is recommended to meet different loads on the ventilating system due to changing weather conditions. There is agreement by all on one phase of this subject — that at certain times the amount of air change must either be reduced or increased to maintain desirable temperatures in the stables.

VENTILATION DESIGN CONSIDERATIONS

Design of a ventilation system requires consideration of (1) the barn construction and insulation in relation to infiltration and transmission heat losses and surface temperatures, (2) the locations with respect to temperature zones, and (3) the heat and moisture production of the animals to be sheltered, considered along with the desired stable temperatures and the moisture load of the outside air. The design factors for dairy barns are well presented in the references cited.

Further data which are to be obtained in the psychroenergetic laboratory at Columbia, Missouri, on heat and moisture production of animals under various environmental conditions are essential to the design of ventilation systems for dairy barns. A further study to determine the effect on the health, comfort, and efficiency of production of animals by supplying various amounts of air is also important.

The second section of this discussion, that of forced ventilation for poultry houses, has been carefully analyzed and presented in an article by Kable[5]. Much of what I shall say has been taken from the same sources as those used by him.

The need for ventilation of poultry houses is now considered primarily to be for minimizing moisture condensation on the walls and ceilings, to keep litter dry and to remove foul odors. It is stated by some writers that it is desirable to maintain a purity of air of 9 parts of CO_2 to 10,000 parts of air. A higher percentage of CO_2 may be maintained without apparent harm, for experiments with poultry have been carried out for many days in succession with concentrations as high as 0.5 to 1 part of CO_2 per 100. At the Iowa Agricultral Experiment Station it was found that 11 parts to 10,000 could be obtained with a circulation of 4.2 cu ft of air per hour per bird.

Certain functional requirements in designing laying houses for poultry have been published by Ashby et al[1]. Those pertaining to temperature, relative humidity and litter moisture are quoted in part as follows:

"Temperature requirements in the laying house are affected by climate and by feeding and management practices. Available information indicates that in houses for commercial egg production with ordinary feeding, winter temperatures above the following minimums are desirable:

Zone	Ordinary	Extreme
1	32 F	15 F
2	40 F	20 F
3	45 F	25 F
4	50 F	32 F

"There should be enough air change through the house to keep the relative humidity below 80 per cent in ordinary winter weather.

"The moisture content of the litter should not exceed 40 per cent (wet basis), as wet litter increases the number of dirty eggs and adds to the labor of caring for the flock."

During cold periods regulation of the rate of air change in the poultry house is necessary to avoid excessively low temperatures. In uninsulated houses this regulation may consist only in closing windows or curtains during storms and cold snaps, since moisture condenses on walls and ceilings and in the litter, if the house is closed tightly enough to raise the temperature more than a few degrees. Gunness of the Massachusetts State College reports that he has "had good results in an uninsulated 100-hen pen by recirculating 300 cfm and drawing in 100 cfm. The recirculation within the house helps to dry the litter and seems to help in preventing frost accumulation on the ceiling. The temperature has been kept higher than would have been possible with natural ventilation."

Continuous restriction of ventilation is practical in a well-insulated house, but even in insulated houses relatively large rates of air change are needed to keep interior surfaces and litter dry because of the water exhaled and voided by the hens. Recent results published by Barrott and Pringle[2] indicate that a 5.35 lb Rhode Island Red hen exhales 0.077 lb of water per day when the hen is fasting and closely confined at 40 F. There is, in addition, an estimated amount of about ¼ lb of liquid in the droppings (the quantity of moisture varying somewhat with kind of feed) a total of about ⅓ lb of water per day, besides certain water spillage by the birds. Experiments are being started in the near future at Beltsville, Md., to measure exact amounts of moisture given off by hens under different environmental conditions.

Under these assumptions it is necessary to remove about ¼ pt of moisture per hen per day to keep the moisture in the litter below 40 per cent. If none of the moisture in the droppings was removed by evaporation and ventilation, but all had to be absorbed, about 12 lb of litter per month per hen would be needed. The air change required to remove the moisture varies with temperature and relative humidity outside and inside the house. For example, with a temperature of 10 F, and a relative humidity of 80 per cent outside, of 15 F and 80 per cent inside, as in an uninsulated house, about 350 cu ft of air per hen per hour would be needed to remove ¼ lb of moisture per hen per day. With the same outside conditions, but with 35 F temperature and 75 per cent relative humidity inside, as in a large well-insulated house, about 60 cu ft would be sufficient.

The hens can furnish only part of the heat necessary to warm the house and remove the moisture during cold weather. Since 25 hens occupy more floor space than one dairy cow, but emit only one-third as much heat, the need for additional heat or heavier insulation is greater in the poultry house than in the dairy barn.

ELECTRIC HEATING-VENTILATION COMBINATION

In the areas of much winter sunshine (Fig. 2) the sun is a valuable source of heat and in a house with floor or walls in contact with the ground the heat from the earth helps to warm the house whenever the air temperature is lower than that of the ground. Ground heat helps especially to avoid extreme drops in the house temperature during cold spells. In weather with average temperature below 10 F and less than 5 hr of sunshine daily, the combined heat from the hens, the sun, and the earth is not enough to maintain desirable temperatures and dry litter unless the house is unusually well insulated. Small quantities of supplemental heat applied under the litter or supplied by thermostatically controlled jacketed stoves or small hot water heaters would greatly improve conditions in cold weather. The use of electric soil heating cable as a source of heat beneath the litter, together with electric fan ventilation is being tried experimentally in several poultry houses near Rochester, N. Y., this winter under the joint direction of Cornell University and the local power company.

There are a number of systems for ventilation of poultry houses including that by electric fans. The basic requirement of any system is to provide uniform air movement through the house without drafts, especially in the roosting area, and provide freedom from excessive air changes due to wind or sudden variations in outside temperature. Electric fan ventilation is the only type subject to thermostat or humidistat control, but its use can be justified only on the basis of a more effec-

tive, cheaper or more reliable ventilation job than that of other systems.

Another phase of forced ventilation for poultry houses, which deserves and no doubt will receive more attention, is that for minimizing temperatures during hot weather. A report of poultry house cooling by Tavernetti[11] from the California Agricultural Experiment Station was made in 1940 on tests conducted in 1938 and 1939. In the experiments, regular university-type poultry houses 16 by 18 ft were equipped with evaporative-type coolers capable of giving one air change in the house per minute. The thermostat was set to turn the cooler on when the temperature went above 85F and off below 80F. During both years one cooled house and one check house were used. Egg production during 1938 was approximately the same for the 8-month period for both houses but greater in July, August, and September for the cooled house. During 1939, egg production was 15 per cent greater per bird for those in the cooled house for the entire 8-month period. Mortality was greater during both years in the check house than in the cooled house, particularly during the summer months.

It was stated that no trouble was experienced in maintaining a temperature of less than 90F in the cooled house even on days when the outside temperature was as high as 110F. This is particularly valuable information in view of the recent report by Barrott and Pringle that the upper temperature limit for survival for 24 hr of mature birds is 90F, with relative humidity of 50-60 per cent.

The conditions under which this finding was made were not the same as those in which a hen normally exists for the birds were closely confined and had no food or water for 24 hr. It is worth noting, however, that the results in California were obtained in regular houses under existing conditions. In 1938 mortality in the cooled house during the period May 27-October 13 was 19.6 per cent and in the check house 27.6 per cent. During the same period in 1939 mortality in the cooled house was 25.8 per cent and in the check house 31.6 per cent.

In conclusion, we wish to emphasize certain points. Past research and experience have provided some information on the design of systems of forced ventilation for dairy barns and poultry houses. However, basic data on the effects of temperature, humidity, air supply, etc., on production and health of the animals are inadequate. It is expected that the psychroenergetic laboratory at Columbia, Mo., and new poultry housing laboratory at Beltsville, Md., will obtain additional necessary information on the amounts of heat and moisture emitted under various conditions. Further research based on these future findings of the two laboratories should provide the answers on electric ventilation.

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Corn and Grain Conditioning

(Continued from page 401)

through the diffusion space between several extended surface heating coils. Coal is used for fuel and water as the heat carrier. A blast of cool air is blown through the heated grain to remove moisture and cool it as it passes through the cooling space. The discharge rate is regulated by the engine speed and the speed of the discharge mechanism.

A summary of the results of the two tests is given in Table 7. The tests include two water temperatures and two

TABLE 7. CONTINUOUS DRIER
Heated Grain – Unheated Air

	Test 1	Test 2
Soybean Moisture Content		
Before drying (wet basis)	14.2 %	15.1 %
After drying (wet basis)	11.8 %	13.0 %
Water Temperature (Avg)		
Into coils	218 F	180 F
Out of coils	206 F	170 F
Maximum Grain Temperature	165 F	143 F
Engine Speed	900 rpm	1,000 rpm
Water Removed Per Hour	183 lb	120 lb
Coal Consumed		
Per hour	48 lb	42 lb
Per hr per 1% reduction	21 lb	20 lb
Dryer Capacity Per Hour	39 bu	48 bu
Fuel Cost Per 100 Bu Per 1% Reduction	20 ¢	17 ¢
Moisture Reduction	2.9 %	2.1 %

engine speeds; however, each test includes several runs. With capacities of 39 and 48 bu per hr, the moisture was reduced 2.1 and 2.9 per cent, respectively, at fuel costs of 17 and 20c per 100 bu for each per cent reduction.

The coal used per hour, for each per cent moisture reduction, was similar in both tests. The fuel cost was slightly less with the lower water temperatures and greater capacity. The capacity could be increased by using higher fan speeds to increase the air volume.

With a water temperature of approximately 220F at the inlet to the transfer coils, and an engine speed of 900 rpm, the temperature of the grain from the drier was more than 100F. This is higher than would be desirable for placing in storage.

Soil Erosion Studies

(Continued from page 405)

Terraces and other contour ridges and channels are also used to reduce the value of $V^2/2g$ and M and thereby reduce the factor D'_3.

One of our big research jobs is that of determining how each of the various erosion control practices operate, and then to devise experiments to evaluate each practice as an erosion check. As a first step in doing this we will add an R' factor to equation [3], and it will then read

$$D'_1 = f[D'_2, (V^2/2g)\ M\ \beta\ R'] \quad [4]$$

The work has not progressed to a point where we can outline methods to evaluate R' for each erosion control practice. However, the studies are being continued, and suggestions and criticisms will be welcomed by the authors. In the meantime, it is believed that some clarification of the problem has been achieved through identifying the more important factors involved in soil detachment by the scour erosion process. In addition to the factor of flow energy, these include differences in the detachabilities of soils and variations in amounts and abrasive characteristics of materials in transport. It is apparent each of these factors must be evaluated in any comprehensive study of soil detachment by the scouring actions of surface flow.

Installing Ground-Water Piezometers by Jetting for Drainage Investigations

By A. F. Pillsbury and J. E. Christiansen
MEMBER A.S.A.E.

GROUND-WATER observation wells are essential in studying ground-water regimes in connection with drainage investigations[2,3,5,6,7]*. A knowledge of the hydraulic gradient is particularly useful, and can be obtained when observation wells are installed so as to read the hydraulic head, or the height of the piezometer surface for a definite point[2,3,6,7]. Such wells are referred to as ground-water piezometers. Piezometers have been installed by driving [2,3,6], by driving combined with a bored hole[5,7], and by hydraulic methods[7]. A simplified and rapid variation of the jetting technique as used for small diameter wells[1] has been developed in connection with current drainage investigations in the Coachella Valley. So far, piezometers have been jetted down to depths as great as 75 ft. Depths in excess of 20 ft are difficult to obtain with the hand-driving method previously described[2,3]. Satisfactory data have been obtained as to the depths, and qualitatively, as to the nature of the various strata encountered. When these piezometers were used in conjunction with a pumping test from an experimental drainage well, it was found that each gave a prompt and accurate measurement of the hydraulic head in the particular stratum intercepted, as indicated by the consistent data obtained with different piezometers.

This paper was prepared expressly for AGRICULTURAL ENGINEERING. The investigations referred to herein were conducted under a cooperative agreement between the Coachella Valley County Water District; the U. S. Regional Salinity Laboratory, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture; and the University of California. The investigations were conducted because it is anticipated that conditions will change with the importation of Colorado River water[4] and not because there are now any major drainage problems.

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*Superscript numbers refer to appended references.

Fig. 1 Installation of a 75-ft ground-water piezometer in Coachella Valley, Calif., using the jetting technique. Water supplied by the spray rig on the right was pumped down the ⅜-in standard pipe at a pressure of about 200 psi

Future plans for continuing and expanding the drainage investigations in Coachella Valley call for the construction of a rig which should eliminate much of the labor now involved, and which should make possible the obtaining of much more precise information on the nature of the strata through which the piezometers are jetted. However, the method used makes practical the obtaining of excellent information on the nature of the soil profile and on the ground-water regime.

Method of Installing Piezometers. The installation of piezometers by jetting was suggested by J. I. Easley, manager of the ranch on which the work was done. Mr. Easley also furnished equipment and assisted with the installations. Standard ⅜-in pipe was used, marks being painted on the pipe at foot intervals for use in obtaining the log. The top of the pipe was connected through a pressure hose to a spray rig rated to deliver about 7 gpm at a pressure of 200 psi. The pipe was plumbed with guides on a portable platform, and special care was taken to stand the pipe vertically. One man on the platform and one or two men on the ground worked the pipe up and down while water jetted from the bottom. With each downward stroke, the pipe was allowed to drop as far as possible. As soon as one section of pipe had been jetted down, another was coupled on, and so on until the desired depth was reached. Fig. 1 shows a piezometer being installed.

The water discharged from the pipe normally flowed to the surface through an annular space around the outside of the pipe, carrying the jetted material up with it. This also served to lubricate and stabilize the hole so that the pipe could be readily oscillated up and down. Sometimes, when a highly permeable aquifer was intercepted, the upward flow would cease momentarily and the pipe would tend to stick. Occasionally, when jetting was stopped to add a length of pipe, the piezometer stuck and considerable force was necessary to break it loose and lift it a foot or two so the pipe could be oscillated up and down again. Once a soil tube jack was used to lift the piezometer and start it again when stuck.

Two or three men worked the pipe up and down. One additional man held the pipe to get the feel of the material it was passing through, and called out data on the depth and nature of the material to the notekeeper. After the pipe was measured and marked and equipment was ready, it generally took about 20 min to put down a set consisting of a 23-ft and a 55-ft piezometer. Nineteen sets of two, and one set of eight, piezometers were installed at distances of 50, 100, 200, 400, and 800 ft from the well in the four cardinal directions.

The coarseness of sand or fine gravel could be roughly judged by the grittiness of the feel as the pipe was dropped. Clay had a hard solid feel, and progress was slow. Progress through silt and fine sand was very rapid, but the silt had a smoother feel. Texture was further substantiated by the nature of the material carried to the surface by the effluent on the outside of the pipe, and by the amount of such flow.

Attempts were made to stop the piezometers with the lower end in sand or gravel to insure rapid response to hydraulic head changes. At each location the deepest piezometer was placed first, and the lengths of shallower piezometers were selected from the log of the deepest one.

As soon as the piezometer reached the desired depth, the

pump was immediately shut off before the material in suspension around the outside of the pipe was carried to the surface. This material quickly settled to the bottom of the annular space and formed an effective seal around the pipe. Later, additional silt was repeatedly flushed down into the annular space around the pipe until the hole was filled. At first, it was thought that the jetting method of installation might leave an annular space around the piezometer that would interconnect various strata and cause errors in readings, but the results obtained dispelled any doubt about the validity of the readings.

After jetting, the piezometers were flushed out using a jet from a length of plastic tubing which was run down to the bottom of the pipe. The spray rig was also used for this operation. The flushing was continued until clear water flowed from the piezometer and the water level would drop readily when the plastic tubing was removed from the piezometer. Sometimes, when the bottom of the pipe rested on clay, despite efforts to avoid this condition, it was necessary to flush through the clay stratum or lift the pipe slightly, before the piezometer would take water readily. Levels were run to the tops of the pipes which served as reference points for the readings. A calibrated electric sounder [2,3] was used for determining the water level in the piezometers. Each reading required about ½ min to make.

Data Obtained from Piezometers. Piezometers were read prior to the starting of test runs on the drainage well, and at frequent intervals during those runs. This made available data to plot curves of the relation of drawdown to time for the well and each piezometer. Fig. 2, plotted from such drawdown curves, shows hydraulic head profiles in the four cardinal directions for a run started February 28, 1946. A correlation of hydraulic head readings with the logs obtained by jetting showed the existence of a perched water table. The upper group of strata (from 7 to 33-ft depth) was separated from the lower group of strata (from 50 to 75-ft depth) by a series of clay strata of low permeability which formed an effective barrier to vertical flow.

It is interesting to note that the upper strata did not significantly respond to operation of the pump. Access from these strata to the well was poor because of faulty well construction. However, there was a small trickle of water flowing from the upper strata to the lower strata through the well when the pump was not in operation. This is evidenced in Fig. 2 by the zone of depression for the upper strata, and by the level of water in the well which, under static conditions, was above the level of water in the lower group of strata.

There are two conspicuous irregularities in the records shown in Fig. 2. After the test had been under way somewhat over one hour, it was noted that the deep piezometer 100 ft east of the well was not responding properly. It was flushed again, and performed satisfactorily thereafter. Also, the deep piezometer 200 ft west of the well did not show water levels conforming to the rest of the data. Considerable work was done on this piezometer. Attempts were made to wash additional silt down on the outside of the pipe. Also, it was reflushed several times, and rapid response was obtained. Two explanations suggest themselves: (1) that because of failure to obtain a satisfactory seal around the outside of the pipe, water flowed from the upper strata to the lower strata, thus raising the piezometric surface in the lower stratum intercepted, or (2) that the stratum intercepted was a minor intermediate stratum, not connected with the general deep strata found elsewhere. In this respect, levels here fluctuated very closely with a very thin aquifer found at 42-ft depth at location 100 N. This inconsistency could and should have been explored before tests were started.

CONCLUSIONS

This preliminary work has demonstrated that (1) a network of piezometers over the trough of the valley, placed by jetting, will give information on the nature of the shallow ground-water strata and on the pressure and direction of movement of water in those strata; (2) such piezometers will be useful in determining the efficiency of various drainage methods tried in future experiments, and (3) the jetting method is feasible in the Coachella Valley,** and provides a cheaper and more rapid method of installing piezometers to greater depths than methods heretofore used.

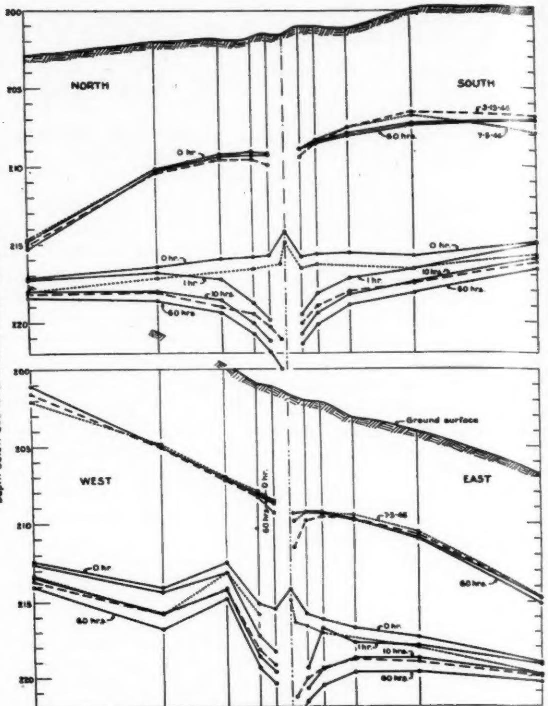

Fig. 2 Piezometric surfaces at drainage test well No. 1. Top curves are for shallow group of strata, and bottom curves are for deep group of strata on each chart. Hours shown are hours after run started on February 18, 1946

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**The jetting method was subsequently successfully used by Dr. D. F. Peterson at Delta, Utah, in connection with cooperative drainage studies by the Salinity Laboratory and the Utah Agricultural Experiment Station.

The Mechanics of Rice Drying

By Harold A. Kramer
MEMBER A.S.A.E.

A KNOWLEDGE and understanding of some of the fundamental laws of physics which apply to the drying of rice are very helpful to the drier operator. This knowledge, together with his observations and experience, will help him to understand the reasons for variations in the milling quality of dried rice and will greatly aid him in improving his drying methods.

Fundamentals of Rice Drying. Combined rice normally contains about 14 lb of excess water per barrel, which must be removed before the rice can be satisfactorily stored or milled. (One barrel is equal to 3.6 bu, or 162 lb.) A practical method for removing this excess moisture is to evaporate the water and remove it as a vapor.

Evaporation requires energy in the form of heat. To evaporate one pound of water requires in round numbers about 1000 Btu, or the total heat required to dry one barrel of combined rice of normal or average moisture content is equal to that amount required to raise the temperature of about 14,000 lb of water 1 F (degree Fahrenheit). Nature supplies this same amount of heat to rice dried naturally in the shock in the field from the vast amount of energy supplied by the sun.

The most practical method for artificially removing the excess moisture is to pass warm air through the damp rice. The heat from the air supplies the energy required for evaporation and at the same time tends to maintain a greater vapor pressure within the rice grain than exists on the exterior. This difference in vapor pressure largely governs the rate at which moisture will move from the interior to the exterior of a rice grain.

Another very important function of the warm air is to provide a medium for carrying away the water vapor liberated by evaporation. The amount of water vapor which air can hold or transport is governed by its temperature. A pound of air which is saturated at ordinary atmospheric temperature can be made to carry an additional amount of vapor equal to what it already has by raising its temperature 25 to 30 F.

The humidity of the air in South Louisiana is usually high. About 2,000 cu ft of warm air are required to absorb and carry away one pound of water vapor, or about 28,000 cu ft are needed to dry one barrel of rice.

There are a number of factors which govern the rate at which water can be evaporated from rice. Surface moisture which is present when the moisture content is high is very easily removed as the evaporation takes place from a free water surface. Internal moisture is more difficult to remove as the diffusion of moisture to the surface is relatively slow, due to the dense kernel and somewhat impervious hull of the rice grain. The deviation of the drying rate from the rate of free evaporation will depend upon the time required to bring the moisture to the surface. Diffusion of moisture to the surface will be quite rapid at first, but as drying advances the process becomes slower until a condition of equilibrium is reached and further evaporation ceases. The ultimate rate of drying is thus governed by the rate of both evaporation and diffusion.

To reduce the total time for drying to a minimum and thereby increase the capacity of the drier, it is good practice to expose rice to drying air at intervals. After the surface moisture has been evaporated, the rice is placed in storage for a time until the moisture has again become evenly distributed throughout the grain. It is then again exposed to the drying air.

Since heat is needed in drying, both to supply energy for evaporation and to maintain a difference in vapor pressure which causes internal moisture to diffuse to the surface, the drying air temperature should be as high as possible without damaging the rice. The upper safe limit for this temperature is probably about 130 F.

Warm air, which supplies heat for drying and carries away moisture, should be supplied at the rate of 350 to 400 cfm for each barrel of rice being dried. The practical limit for the relative humidity of the air leaving the drier is about 75 per cent. To obtain uniform distribution of air throughout the drier without excessive static pressure, it is important that the lineal velocity of the air in the ducts does not exceed 2,000 fpm. When this precaution is observed the static air pressure at the blower need not exceed 3/4-in water pressure.

Evaporation requires heat. Where heat is largely supplied by warm air passing through the rice, the greater the rate of evaporation, the greater the drop of temperature between the inlet and outlet air. The temperature of air will drop approximately 8 1/2 F for each grain of moisture absorbed per cubic foot of air measured at 70 F, or 0.64 deg for each grain absorbed per pound of air, where no heat has been lost to the rice or drier itself. As the drying rate decreases, there is less cooling by evaporation, and finally the temperature of the rice and the outlet air will increase and gradually approach the temperature of the inlet air. These temperatures are the best indication of what is actually happening to the rice in the drier and should be closely observed by the drier operator.

It is recommended that the temperature of rice should not be allowed to exceed 110 F for best drying results. This temperature can be determined by catching a sample of rice from the drier in a container and inserting the bulb of an ordinary laboratory thermometer into the interior of the sample.

Fig. 1 Scale model of experimental individual-type farm rice drier. One side of air duct leading from blower to main drier section is of transparent material to show inlet ports leading to inverted section shown in Fig. 4

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Biloxi, Miss., January, 1947.

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Suggested Drying Procedure.

A Start with good quality rice

1 Rice should not be chalky, pecky, etc.
2 Rice should be of uniform ripeness. Overripe grains usually are sunchecked
3 Rice should be well combined and have a minimum of hulled grains
4 Rice should be combined at 22 to 26 per cent moisture content.

B First drying

1 Begin within 6 hr after combining
2 Dry for 30-45 min at 130F.

C Second drying

1 Begin 6 to 12 hr after completion of first drying
2 Dry for 20-30 min at 130F.

D Third drying, and additional dryings required to reduce the moisture to 14½ per cent

1 Begin 6 to 12 hr after completion of previous dryings
2 Dry for 20 min at 130F.

E Last drying

1 Begin within 24 hr after previous drying
2 Dry without artificial heat unless atmospheric humidity is above 75 per cent
3 Dry until rice temperature is as low as the atmospheric temperature.

Low Yield of Head Rice. Occasionally a lot of artificially dried rice is received at the mill which yields fewer pounds of head rice than is normal for that variety. Investigation of the reasons for the low milling yield usually reveals one or two causes. The rice kernel may be fractured in the drier by too rapid drying with excessive heat or cooling. In many cases, however, where a sample of the original rice, which was dried naturally, is available for comparison, it is found that the quality of the rice was poor when it first reached the drier.

Another common complaint is that rice has been stackburned by the drier. Stackburning is occasionally found in artificially dried rice but does not occur in the drier. Experimental work conducted by Max Milner at the Minnesota Agricultural Experiment Station and others shows that certain molds, bacteria, and fungi are almost invariably present on normal rice grains, even though the rice has been grown and harvested under ideal conditions. Their presence is entirely harmless as long as conditions are unfavorable for their growth.

When the moisture content exceeds the minimum for the reproduction of these organisms and temperature conditions are suitable, abundant growth is produced. This condition prevails when the relative humidity of air surrounding the rice grains reaches or exceeds about 75 per cent at a minimum temperature of about 77F. Growing organisms produce moisture and heat as end products of their respiration and also excrete powerful digestive ferments which act on the starches, proteins, and fats, which are readily available near the bran layer of the rice grain.

The occurrence of stackburn can best be prevented by limiting the length of time between dryings. The common practice of allowing the temperature of rice to rise in the bin between dryings is not recommended. The temperature of dried rice should be reduced to atmospheric temperature before it is placed in final storage.

Weight Loss Due to Drying. When rough rice is dried artificially, or naturally in the shock in the field, there is always a loss of weight. The loss of weight is due to the removal of moisture, and the percentage loss of weight due to drying is always greater than the reduction in the percentage of moisture. This difference exists because as the rice is being dried there is a constant change of base in making the moisture test.

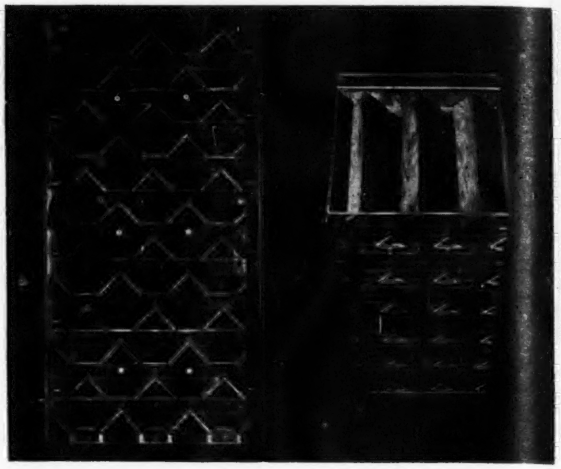


Fig. 2 Two views of main drier section showing arrangement of inverted sections within drier and location of outlet ports

The algebraic calculations for the final weight of a barrel of rice, after drying, may be made as follows:

$$\text{Final weight} = \text{original weight} - \text{weight lost due to drying} \quad [1]$$

$$\text{Weight lost due to drying} = (\text{original weight} \times \text{original per cent moisture}) - (\text{final weight} \times \text{final per cent moisture}) \quad [2]$$

As an example, assume 162 lb of rice are dried from 24 per cent to 14 per cent. Transposing these values into equation [2] and then in turn into equation [1], we have:

$$\begin{aligned}\text{Final weight} &= 162\text{ lb} - (162\text{ lb} \times 0.24 - \text{final weight} \times 0.14)\\ &= 162\text{ lb} - 38.88 + 0.14\text{ final weight}\\ &= \frac{162 - 38.88}{0.86} = 143.16\text{ lb.}\end{aligned}$$

Note that in this case the reduction in moisture is 10 per cent while the reduction in weight due to drying is 11.63 per cent.

Another form of the same equation which is more easily remembered is as follows:

$$\begin{aligned}\text{Final weight} &= \frac{\text{original weight} \times \text{original per cent dry matter}}{\text{final per cent dry matter}}\\ &= \frac{162\text{ lb} \times (100\% - 24\%)}{(100\% - 14\%)} = 143.16\text{ lb}\end{aligned}$$

In addition to the weight lost due to drying, there is usually some loss in weight due to the blowing out of small particles of broken grains, dust, and hulls. Where the rice is cleaned during the drying process, additional straw, weed seeds, and foreign material are removed and the total weight loss may be as much as 2 per cent for each per cent of moisture removed by the drier. The average weight loss on over 69,000 barrels of rice dried at the Crowley Rice Drier Co-op., Inc., Crowley, La., during the 1945 drying season, was 9½ per cent.

Cleaning Combined Rice Before Drying. Combined rice usually contains varying amounts of straw, grass, weed seeds, etc., which add considerably to the total moisture of the sample. As an example, moisture tests made on an exceptionally dirty lot of rice showed the average moisture to be 37½ per cent. The rice only was then removed from the sample, and it contained only 22 per cent moisture. The wet foreign material in combined rice not only cuts down on the capacity of the drier, but also interferes with the uniform flow of the rice in the drier, bins, and conveying system.

Combined rice, which has not been dried, is difficult to clean. Many of the weed seeds will pass through the same

size screen opening as rice, and when wet are too heavy to be removed by air. One of the greatest problems is to obtain sufficient cleaning capacity in barrels per hour without excessive cost for cleaning equipment.

A coarse screen is probably best for removing the larger pieces of straw and other material which interfere with the uniform flow of rice. One of the best commercial cleaners observed uses a revolving screen cylinder for removing the larger pieces and an air blast for the smaller and lighter dust, chaff, hulls, etc.

When rice is artificially dried, a great deal of dust is produced. This is because the rice hulls and other foreign matter are more porous or smaller than the rice kernel itself and become very dry and brittle. The transferring of rice from bin to drier and return causes these brittle pieces to break up into smaller pieces. Some varieties of rice such as Blue Rose have a fuzz on their hull which when dry is easily rubbed off.

SCREEN ANALYSIS OF DUST OBTAINED AT THE
Crowley Rice Drier Co-Op., Inc., Crowley, La.

Sample A. Settled dust from ledges near drier
Sample B. Settled dust deposited by air currents only

	Sample A, per cent	Sample B, per cent
Through 325 mesh	25.3	49.7
325 - 200 mesh	18.9	23.3
200 - 100 mesh	7.2	18.4
100 - 65 mesh	9.4	4.0
Under 65 mesh	39.2	4.6

Dust Control in the Drying Plant. To avoid much of the annoyance and inconvenience of dust, it is recommended that all driers be enclosed. The drier enclosure should be large enough to act as a settling chamber to remove the heavier particles of dust from the air stream. The exhaust opening from the drier enclosure should always have an area at least equal to the total area of the blower outlets leading into the enclosure. This is necessary to avoid back pressure on the blower.

Where better separation of dust from the drier air is necessary than is possible with a simple settling chamber, an air washer is recommended. The greatest factor in the elimination of dust in an air washer is a properly designed scrubbing surface wetted and washed down with low-pressure water sprays. The air flowing through the washer should be divided by the scrubbing plates into as narrow layers as practical in order that as great a contact surface as possible may be secured, and so that the dust particles in the air will have a relatively small distance to travel before coming in contact with a wetted surface. In addition to the scrubbing plates, it is advisable to provide a chamber with water spray so arranged that the spray is directed toward the plates and in the direction of the air flow. The washer should be supplied with a settling tank, through which the spray water is recirculated to remove dust particles. Provision should be made for draining and refilling the settling tank as this must be done periodically. A centrifugal pump is used to circulate the spray water.

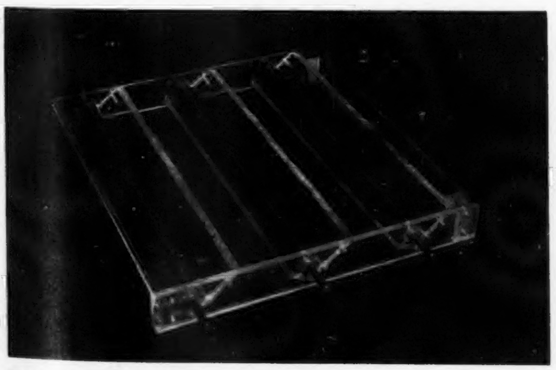


Fig. 3 View of feed roll section removed from its location between main drier section and discharge hopper, where it controls rate at which grain may pass through the drier

A source of much of the dust in a drying plant is where the elevators discharge partially dried rice into the receiving hopper of the drier. Most of this dust and larger foreign material such as dry straw can be removed here by passing the rice through an aspirator.

Another source of dust is at the discharge of the drier. This dust is produced by the movement of the rice in passing through the drier. Since this dust is very dry and consists mostly of very small particles it is easily removed by air. In most cases a suction applied to the discharge spout leading from the drier to the elevator will be sufficient.

Where dust is systematically removed from the rice at the locations mentioned it does not have a chance to accumulate. By placing covers on the conveyors most of the remaining dust is prevented from escaping.

Where complete dust control is necessary or desired the recommendations given in USDA Department Bulletin 1373, "Dust Control in Grain Elevators", will be found helpful.

Another good reference on dust control is Engineering Service Department Bulletin No. DC-200A, which can be obtained from the Mill Mutual Fire Prevention Bureau, 400 W. Madison St., Chicago, Ill.

Those interested in the explosive properties of rice dust are referred to USDA Technical Bulletin No. 490, "Explosibility of Agricultural and Other Dusts as Indicated by Maximum Pressure and Rates of Pressure Rise", or may obtain more recent information by writing direct to Hylton R. Brown, senior engineer, Bureau of Mines, U. S. Department of Interior, Eastern Experiment Station, College Park, Md.

Moisture Testers. The principal advantage of the electric-type testers is in the rapidity with which tests can be made. For this reason they are very popular with rice drier operators, who need to know at all times the approximate moisture content of each lot of rice. These testers have been calibrated with clean rice of uniform moisture content, and when testing such rice are very accurate. Wet combined rice is seldom uniform in moisture content and usually contains varying amounts of weed seed of high moisture content, which makes it very difficult to obtain a true average moisture reading. Rice which has just passed through a drier is not of uniform moisture throughout the entire grain and unless allowance for this is made the true moisture is not obtained. For this reason some drier operators have been led to believe that moisture content of rice changes appreciably while in the bin between dryings.

The Brown-Duvel tester, if properly operated, will give the true moisture of a sample of rice regardless of foreign matter, temperature of the rice, or uniformity of drying. The principal disadvantage of this tester is that about 30 min are required to complete a moisture test. Complete instructions for the operation of this tester are given in USDA Bulletin No. 1375D, "The Brown-Duvel Moisture Tester and How to Operate It."

All types of moisture testers are calibrated and checked by oven drying a part of the sample being tested. This method is extremely accurate and is standard for all types of moisture tests, but requires considerable time. Information on the procedure for making this type of test is given in USDA Agricultural Marketing Service, Service and Regulatory Announcement No. 147, "Air-Oven and Water-Oven Methods Specified in the Official Grain Standards of the United States for Determining the Moisture Content of Grain."

Seed Rice Drying. Seed rice may be dried artificially without damage to the germination. Very good results have been obtained in experimental work by continually rotating the seed rice from bin to drier and then to another bin, etc., until dry. An inlet air temperature of 120 F and a 20-min drying period were used. This method of drying reduces the capacity of the drier somewhat, but eliminates the possibility of mold or fungus attacking the germ of warm damp rice while in the bin between drying periods.

Before drying a lot of seed rice it is extremely important that the drier, bins, and conveying system be thoroughly cleaned in order that there will be no mixing with other va-

rieties. The seed rice drier should be of a self-cleaning type. The bins should be free of projections or ledges on the interior, and the elevator boots easily cleaned. Screw conveyors can be cleaned with a small portable electrically driven hand blower. The dust covers are removed and, with the conveyor running, cleaning is started at the receiving end and proceeds to the discharge end. As rice is piled up by the blast of the blower, the next conveyor flight picks it up and carries it to the discharge end.

Heat Supply for Drier. The amount of heat required for warming the air used by a rice drier depends upon the initial temperature and moisture content of the air. The approximate quantity of heat required to raise the temperature of one pound of air and its moisture one degree Fahrenheit is about 0.246 Btu per lb of the mixture, or about 18.1 Btu per 1000 cu ft of air.

The average mean temperature in the Crowley, La., area during August, September, and October is about 77 F. Assuming 77 F initial temperature, 130 F maximum temperature, and with no heat loss, a total of about 1 Btu of heat is required per minute for each cubic foot of air used by the drier.

To take care of lower initial air temperature, heat losses, and periods of above average humidity, it is recommended that enough heating capacity be provided to supply about 2 Btu per min for each cubic foot of air used.

The most satisfactory source of heat for a rice drier is natural gas or butane gas. Gas burners are relatively inexpensive and are easily regulated to maintain a desired air temperature. Because a clean flame is produced, the burner can be directed toward the inlet to the blower and the products of combustion allowed to pass through the drier.

GROSS HEATING VALUE OF VARIOUS FUELS

Natural gas	1,000 Btu per cu ft
Commercial butane	21,180 Btu per lb 102,600 Btu per gal
Commercial propane	21,560 Btu per lb 91,500 Btu per gal
Gasoline	21,050 Btu per lb 129,000 Btu per gal
Kerosene	20,000 Btu per lb 135,000 Btu per gal

As a safety precaution each burner installation should be equipped with a solenoid valve in the gas line. During normal operation the solenoid valve is held open by electrical energy from the same circuit which drives the blower motor. It should be wired so that in case of current failure the valve is automatically closed and remains closed until manually opened by the drier operator.

Experimental Work on Drying Plants. Preliminary work on the requirements of an inexpensive individual-type farm rice drier was begun during the 1943 rice harvest season. At this time experiments were conducted and data collected, on a full season's drying results, at an existing drying plant owned and operated by Webster and Donald Todd near Holmwood, La. The results of this first season's research provided valuable information on the drying conditions which must be maintained in a drier to insure a maximum yield of head rice.

Following the 1943 harvest season, work on the design of a drier was begun. The following principles were kept in mind: *(Continued on page 417)*

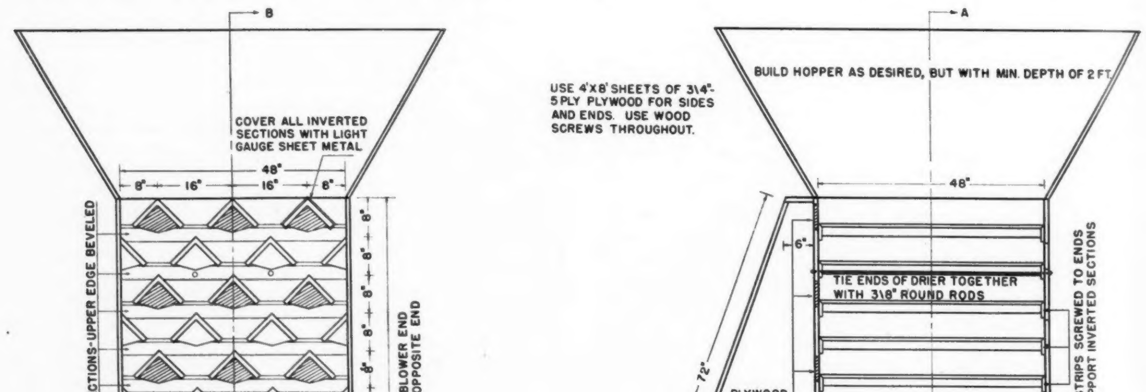


Fig. 4

Sweet Potato Planting Machinery

By Joseph K. Park

MEMBER A.S.A.E.

THE large amount of labor required to produce table-quality sweet potatoes combined with the fact that the crop is being grown more extensively for livestock feed and industrial uses has created an increased interest in developing more efficient production and harvesting equipment. For several years the agricultural engineering divisions of the USDA Bureau of Plant Industry, Soils, and Agricultural Engineering have been cooperating with the Mississippi Agricultural Experiment Station, and during the past year with the South Carolina Station, in studying methods of mechanical production and harvesting and the development of new equipment and practices.

This paper is primarily concerned with planting machinery. However, before considering any specific planting machinery, it will be worth while to review the over-all problem of propagating sweet potatoes. Just what does it involve? The usual procedure at present is as follows: First the sweet potatoes which were saved for seed from the preceding crop are bedded in hotbeds. After a period of 5 or 6 weeks, some of the plants produced in the hotbeds are large enough to start transplanting to a "mother patch" in the field. Transplanting from the hotbeds to the mother patch continues for 5 or 6 weeks and generally involves 4 or 5 pullings from the hotbeds. When the mother patch has been growing for about 4 weeks it begins to send out runners. These runners are cut by hand into 12 or 14-in lengths called "vine cuttings", and finally these vine cuttings are planted in the field. About four or five acres of vine cuttings can be planted from each acre of mother patch.

The engineer's job is to reduce the labor required to produce the crop, keeping in mind all factors which affect profit to the grower. A great deal of interest has been expressed in mechanical transplanters. These are available and their use will result in considerable labor saving in the actual transplanting operation. However, with present practices, simply reducing transplanting labor obviously still leaves a lot to be realized regarding the over-all labor problem. Unless some method is devised to considerably alter present propagation procedures, it will be very difficult to make really substantial reductions in labor required for this phase of sweet potato production.

Present machinery developments are proceeding on the basis of current growing practice. In so far as planting equipment is concerned, there are several transplanters commercially available which may be used for planting sweet potatoes. The most common type of planter consists essentially of a furrow opener followed by packing shoes or wheels. Two men per row are required to ride the machine and drop plants into the furrow ahead of the packing shoes. This type of planter is generally drawn by a horse or tractor but may be mounted directly on a tractor. The direct tractor mounting is preferable since more accurate work can be done and the necessary parts for mounting can be obtained for a considerably lower cost than an entire transplanter. Planters of this general type may be equipped with devices for automatic spacing of plants, with fertilizer distributors, and with water tanks and automatic water valves. When the planter is tractor mounted, the tractor fertilizer distributor is used and a water tank may be mounted at some convenient location.

During the past season at Clemson, a simple rolling disk and pack-wheel device for planting sweet potatoes was built. It consists of a 20-in diameter disk $\frac{3}{8}$ in thick followed by a small pack wheel (Figs. 1 and 2). The plants are laid by hand on the ground ahead of the planting disk. Small projections on the edge of the disk catch the plants and they are pushed into the ground to a uniform depth of up to 8 in, depending upon how deep the planting disk is run. A constant stream of water runs into the narrow furrow left by the planting disk and then this furrow is closed and soil is tightly packed around the plant by the pack wheel. Upon examination of the plants behind this machine, we have always found at least one and generally two nodes well packed in wet soil. This condition is essential if good survival is to be obtained, particularly when the soil is fairly dry. *(Continued on page 417)*

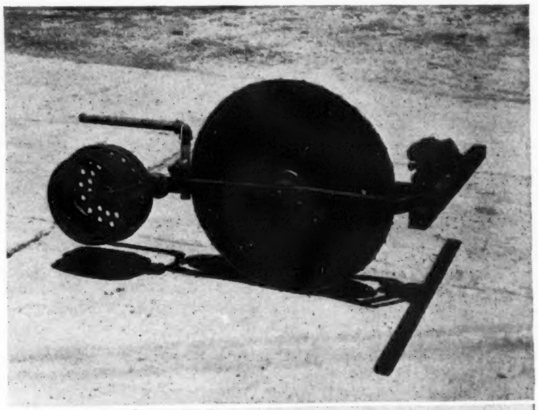


Fig. 1 *(Top)* A disk-type sweet potato planter • Fig. 2 *(Center)* Transplanter mounted on a tractor • Fig. 3 *(Bottom)* Rear view of the transplanter in operation

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Biloxi, Miss., January, 1947.

JOSEPH K. PARK is agricultural engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA, cooperating with the South Carolina Agricultural Experiment Station.

A State Irrigation Program

By Everett H. Davis
MEMBER A.S.A.E.

PROGRESSIVE growers in the Southeast, and Georgia in particular, are discarding the age-worn belief that in a land of 50 in of annual rainfall irrigation is neither necessary nor practical. Destructive droughts often interrupt quality and quantity production and force farmers to limit production of many crops to periods when rainfall is generally available. Drought charts, prepared from the U. S. Weather Bureau data over a period of 15 to 20 years, prove that long dry periods frequently occur during the March to middle November growing season. Despite the heavy annual rainfall these droughts have often lasted for 25 to 30 days. Supplemental irrigation provides the missing link which enables growers to grow quality produce during periods when rainfall is negligible and the markets are favorable.

About 35 farmers, scattered over Georgia, have used irrigation for the past few years, but it was not until 1946 that the "lid blew off" and an irrigation program got under way in earnest. Cason Callaway, father of the 100 Georgia Better Farms, Inc., wanted to see the development of irrigation on at least 25 of the farms. He declared, "I believe irrigation offers probably the greatest opportunity of any one thing toward raising our agricultural income in the State."

Reports at the close of 1946 show that truck growers were paying for their irrigation systems in one season's operation. Tobacco growers saved their late crops with sprinkler irrigation, while others produced 500 lb more per acre with some extra water applied at the right time. Until 1946 no tobacco had been grown under sprinkler irrigation in the Southeast.

A leading north Georgia dairyman, caught in the middle of a long dry period last fall, maintained milk production at a high level during the drought and netted one dollar per acre per day due to irrigation. Supplemental water will pay dairymen dividends in establishing temporary pastures used for winter grazing, by getting them seeded early in the fall when soil moisture is usually deficient.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

EVERETT H. DAVIS is extension agricultural engineer, University of Georgia.

The first pecan orchard irrigation project got under way in April, 1946. The owner of this orchard is certain that water would have made a difference of $10,000 two seasons ago when there was an excellent set of pecans, but dry weather hit at the wrong time and caused the quality of nuts to be substantially lowered.

The first economic study of any multipurpose river development in the state to give serious consideration to irrigation is now being made on the Altamaha Basin Project in middle and southeast Georgia. It has been conservatively estimated that small community irrigation projects can be developed on this project to the extent of increasing agricultural income around $25,000,000 annually.

Most recent irrigation progress has been the successful operation of low-pressure revolving sprinkler systems in connection with flowing artesian wells in southeast and southwest Georgia. This original work has been in progress for several months during which period many wells were tested for flow and discharge pressures measured. Pressures developed by these wells depend principally on elevation and construction of the wells, but range mainly from 3 to 8 psi. In order that this water might be put to more beneficial use, since most of it is now being wasted, the recent development of a low-pressure revolving sprinkler by a leading sprinkler manufacturer is significant. These single-nozzle sprinklers operate smoothly and distribute water satisfactorily within the range of pressures developed by flowing artesian wells.

The installation of the sprinkler irrigation equipment in connection with artesian wells is simple and inexpensive. A self-sealing coupler known as the Pierce coupler, and similar to those used on many types of portable irrigation pipe, can be fitted to any size well casing and made secure without threaded connections. A nipple is welded on the opposite end, to which is attached the irrigation pipe adapter unit furnished as standard equipment by irrigation pipe manufacturers.

Under field conditions, and to assure even coverage, the sprinklers are spaced 20 ft apart on the portable quick-coupler sprinkler line, and these lines are moved at intervals of 20 to 25 ft along the main supply line. In the areas of

Left: Fifteen sprinklers spaced 20 ft on 3-in portable pipe cover 1/6 acre per setting. Flow from artesian well operates sprinklers. Irrigating vegetables and tobacco plant bed (in background) • *Upper Right:* Pasture irrigation is proving profitable to the livestock people, particularly dairymen • *Lower Right:* Tobacco was irrigated by sprinkling for the first time in Georgia and the Southeast in 1946. Portable revolving sprinkler systems are adaptable to all types of crops

flowing artesian wells the soil is of the sandy loam type, and the land is undulating making sprinkling the most practical and efficient type of irrigation.

Growers will make increasing use of artesian water for irrigation purposes and are becoming more and more conscious of the importance of conserving this supply, of which 45,000,000 gal daily are now wasted, according to state and federal geologists. If 50 per cent of this daily quantity was utilized for irrigation of crops, over 2,100 acres of land could be irrigated with this modern sprinkler equipment. State and county officials are expected eventually to take appropriate action to have landowners cap or restrict the flow of unchecked wells as a means of conserving the underground artesian flow. The Georgia Department of Mining and Geology reports that artesian water levels are gradually declining and areas of artesian flow are diminishing[1].

The leadership Georgia has taken in supplemental irrigation and the rapid progress she is now making is due, in large part, to the excellent follow-up activities of equipment distributors after the irrigation engineer has completed his design of a system or made specific recommendations according to local conditions. Three companies in Georgia are handling complete lines of irrigation equipment and are able to provide the grower with a system complete from the foot valve to the last sprinkler in the field. Proper handling of factual information through established publicity channels has contributed to the rapid progress the state is making in irrigation.

Irrigation research work is now under way at four experiment stations covering the field of vegetable crops, permanent and temporary pastures, field corn, and certain small fruits.

[1]Warren, M. A. Artesian Water in Southeastern Georgia. The Geological Survey, Bulletin No. 49.

Sweet Potato Planting Machinery

(Continued from page 415)

The planting disk and pack wheel pivot about a bearing which is welded to a cultivator tool bar. The entire machine is light and easily mounted in the cultivator frame. The water barrel frame is held in place by two drawbar bolts (Fig. 3), and the planter and water barrel can easily be assembled on the tractor by one man in five or ten minutes. Water flow is controlled by the driver by means of a water valve on the bottom of the barrel. This type of planter can be mounted on any tractor.

Depth of planting is an important factor affecting plant survival. Quite often with conventional type planters it is difficult to plant over about four inches deep and, particularly in dry soil, many plants are left practically on top of the ground. These of course have a very small chance for survival. With the planting disk all plants may be set deep in the ground with a minimum of disturbance of the plant bed. Depth of planting is determined by the setting of the pack wheel in relation to the planting disk.

The planting disk can be used most successfully on beds which have not been built too long before planting time. If the beds have been standing several weeks and have become packed by several rains, there is a tendency for fresh plants or vine cuttings to be broken by the planting wheel. However, since the edge of the wheel is more blunt than the sticks generally used in hand planting, it will break fewer plants than are broken by sticks. If it becomes necessary to plant in hard beds, breakage of plants can be avoided by delaying planting a few hours after the plants have been pulled or cut so they will have time to become less brittle. There is a disadvantage in building beds too far ahead of planting time in that this practice results in giving the weeds a chance to get well established before the new plants, rather than vice versa.

Now just how does this planter affect the picture of labor required for transplanting? When hand methods are used, one man drops plants on the row and is followed by two men sticking them into the ground and packing the soil around them. When this is finished, they are often watered from buckets carried by hand along the rows. With this planter, one man on a tractor replaces all the hands who are sticking and watering plants. Therefore, it is estimated that approximately two-thirds of the planting labor is eliminated. This figure of course does not consider the labor of pulling plants from the hotbeds or cutting vines from the mother patch, since these jobs are not affected by the method of planting.

When this planter was first built, it was pulled behind a tractor and seats were provided so that it could be fed by two men riding as is the common practice with conventional transplanters. It was soon determined that planting could be done faster, more efficiently, and with far less skips if plants were dropped on the rows ahead of the tractor, leaving only the driver on the tractor. In addition, the speed of the tractor was no longer limited by the rate at which the two riders could separate and drop plants.

It should be noted that, although not absolutely necessary, it is desirable to have a mark along the top of the bed to show the droppers where the planting wheel will run. This was accomplished by fastening a small piece of metal to the bottom of the board used in boarding off the beds. Fertilizer application, boarding off, and marking for the plants was done in a single operation shortly before planting.

The men at the Edisto Station where most of the field tests were conducted prefer this disk-type planter to anything they have previously used, and have used it to plant their crop this season. It is possible that eventually a planter can be developed which will be completely automatic and effect still further labor reductions. It should be remembered though, that even if planting labor is cut to a very low figure, there is still considerable time required in producing hotbed plants, growing a mother patch, and making vine cuttings. Solutions to these problems will have to be made jointly by the plant breeder, the horticulturist, and the agricultural engineer.

This paper has considered planting machinery only. Work is also being done on other phases of mechanical production and harvesting. Some new machines and methods have been tried and some progress has been made. However, particularly concerning harvesting equipment, the major problems are yet to be solved.

Rice Drying

(Continued from page 414)

1 With optimum drying conditions known and maintained in the drier, each grain of rice should, as far as is mechanically practical, be uniformly exposed to those same drying conditions.

2 The drier should be easy to fabricate using standard types and sizes of materials most readily available.

3 The drier should be easily constructed without an elaborate set of tools and equipment.

4 The drier should be entirely self-cleaning, making it suitable for the drying of seed rice.

5 The drier should be of a size suited to the needs of the small grower.

The first experimental drier was built during the summer of 1944. (Fig. 4 shows the construction of this drier.) During the early part of the 1944 harvest season, it was installed on the farm of John and Floyd Baker near Gueydan, La.

Four 300-bbl capacity round tanks of light-gage steel construction were used for working bins. A receiving hopper for wet rice, two elevators, and necessary screw conveyors were provided. Heat for the drier was supplied by a homemade burner using natural gas. A 7½-hp electric motor supplied all of the power for the elevators and conveyors.

About 10,000 bbl of rice were dried that season at a cost of 18c per bbl. The total cost of the plant was estimated at $5500.

As a result of the research at Gueydan, a second drying plant was erected the following year by Remy P. Robert and Bros. at Burnside, La. The drier is of the same design as shown in Fig. 4 except that it is larger and of steel construction. Plans for the drier, elevators, conveying system, bins, and layout of the complete plant were supplied by the Louisiana Agricultural Experiment Station.

RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

ON AUGUST 18 and 19 at the Delta Branch Experiment Station, Stoneville, Miss., the National Cotton Council of America sponsored a conference on increasing the income of farm workers of the cotton belt through mechanization of cotton and related crops. Cooperating sponsors were the Farm Equipment Institute, the U. S. Department of Agriculture, land-grant colleges, and farm organizations.

A feature of the first session was a discussion of problems of ginning and marketing in the mechanized programs by Charles A. Bennett, engineer in charge, U. S. Cotton Ginning Laboratory. This was followed by a tour of the ginning and fiber laboratories.

The joint project on cotton mechanization under the direction of William E. Meek, USDA agricultural engineer, was a high point in the proceedings of the second session. A small field at the Delta Branch Station was arranged to show all field operations according to project proceedings from seedbed preparation to picking.

Twelve tractors with mounted equipment were operated in appropriate portions of the field. Among the operations demonstrated were precision planting, high-speed sweep and flame cultivation, side dressing with anhydrous ammonia, and ditch-bank burning. The concluding part of the demonstration was cotton dusting by three planes in formation and a helicopter exhibition.

The meeting was well attended by implement company executives and engineers, state experiment station directors and staff members from the whole cotton belt, as well as planters and representatives of all cotton organizations. Emphasis was placed by all speakers on the necessity for accelerated research on and production of equipment to mechanize cotton. The conference went on record to use its influence in mechanizing cotton. More news from this gathering at Stoneville will be forthcoming.

* * * *

Assembling data on measurements of the shrinkage in volume of ear corn during storage is a research project of special interest in a soft corn year. B. M. Stahl is the USDA engineer assigned to this work in cooperation with the Iowa Agricultural Experiment Station. In an empty section of a large crib at Ames a stave tube 20 ft deep and 1.5 ft in diameter was erected, supported on a lever connected to scales and filled with clean corn in October, 1946. A depth marker, consisting of a 1-ft length of lath, was placed on top of each 50-ear load until the tube was level full. Initial moisture determinations were made at the time of filling, and measurements of weight and marker positions have been made at least once each month.

Current indications are that for a 10-ft initial depth a reduction in kernel moisture from 25 to 20 per cent causes a shrinkage of 6 per cent and that for a reduction in kernel moisture from 20 to 15 per cent the shrinkage is 7.2 per cent. In a five-foot initial depth the same moisture changes produce shrinkages of 5.3 and 6.7 per cent.

When the test is ended and curves are plotted for all depths, a reasonably accurate estimate of the effects of moisture and depth on shrinkage should be possible. These values, however, will not provide a complete answer to the practical problem of estimating quantity from volume measurements. Basic volume factors (cubic feet per bushel of shelled corn at 15.5 per cent moisture) will have to be estimated or determined by experiment for corn of normal, high, and low shelling percentages; for normal, poorly husked, and clean corn; for mature and immature corn; for cribs with and without ordinary cross bracing; and for ordinary, deep, and shallow cribs. Corresponding volume factors to use for various kernel moisture conditions can then be found by means of volume ratios.

* * * *

Plan Exchange Service cooperators in all states have just received word from the Division of Farm Buildings and Rural Housing, USDA, that 6 new farmhouse plans are available. With a couple of exceptions, the new plans were prepared especially for the Northeastern Region by the Division and the Bureau of Human Nutrition and Home Economics in cooperation with the Northeastern Plan Exchange Committee. All the plans, however, are suitable for use in some parts of all regions.

Farmhouse activities differ from those in other houses, often including processing or other work related to the farm business. The house itself is also best planned with an eye to the location of other farm buildings, gardens, drives, etc. The plans now being made available to farmers through their state extension services try to meet such special needs of rural living and are characterized by compact design, entrances handy to driveway and farmstead, good traffic circulation, liberal closet and storage space and convenient work centers.

All these houses are of architectural styles suitable in country settings. They range in size from small one-story houses without basement to roomy 1½ story houses that can be finished in stages. One plan is shown in log construction, but all can be built of either frame or masonry. Modular dimensions, as recommended by the American Standards Association, are used in all the plans.

One of the six houses was originally designed and built as a feature of a cooperative research project in Georgia, and it has been proved by 6 years use. Alternate drawings have been prepared for the North with a basement which will house central heating system, workroom, and shower.

Working drawings may be obtained through the extension agricultural engineer at many of the state agricultural colleges. Orders may be placed through county agricultural or home demonstration agents. Some states furnish plans free. Others make a nominal charge to cover printing and mailing. Where the extension engineer cannot furnish the plan, inquiries may be directed to the U. S. Department of Agriculture, Division of Farm Buildings and Rural Housing, Beltsville, Md. The Department does not furnish plans directly but will refer any inquiries received to the nearest state handling the requested plan.

* * * *

On 20 dairy farms in Illinois, 11 in Wisconsin, and 14 in Indiana careful scrutiny is being given the dairy barns, what is in them and what goes on in them. As part of USDA's methods engineering work, Thayer Cleaver is cooperating with the experiment stations of the three states in making time and motion studies of various labor operations in dairying and studying the design, arrangement, and equipment of buildings. The work is only well under way, and more will be learned when certain barns are studied again after changes have been made in structure, equipment, or both.

Cleaver and his associates find the face-in type of stanchion arrangement most convenient for feeding, especially where the front of the manger has no curb above the feed alley, but the milking operation may be longer than in the face-out arrangement. Very few barns are arranged for easiest feeding. All studied to date are faulty in one or more of the following features: location of silo and ground-feed bins; location, size, and number of hay chutes and straw chutes; equipment for measuring and getting feed from storages to the animals. The last feature is particularly important in one-story barns where all feed is brought in from outside or adjoining storage structures.

Most two-story barns have hay or straw chutes over the feed alleys, but seldom enough. Cleaver thinks the minimum for convenience and for saving time and labor should be one for every eight stanchions in the face-out type and one for every ten to twelve in the face-in type if the feed alley is wide enough. He thinks it quite possible that with better feeding arrangements the time and labor requirements for feeding can be so shortened in the face-in type that the difference in milking time between the two types would be more than made up.

Practically all stalls are too short and many are too narrow for convenience and comfort of the cows. Observations indicate that the standing room should be increased in length at least 6 in for at least 75 per cent of all cows in stanchion barns, and another 6 in for at least 30 per cent of them if the cows are to be comfortable when lying down. In many barns the gutter could be pushed back and still allow plenty of room for manure removal, the milking operation, feeding and bedding operations.

Cleaver also points out that frequently small, simple, inexpensive equipment is most valuable. On one dairy farm two pails were fastened together and carried by a short, rigid, convenient handle. One double pail was used for the udder wash and one for the teat cup rinses. They were filled in the milk house, where rinses were prepared, and carried to the point in the barn where milking started. Use of single pails would have required extra trips from milk house to barn. Elimination of this one extra trip each milking saved the operator almost 15 miles of travel a year.

Other good examples of simple, effective devices are milk bottles with large nipples for feeding young calves and hand feed scoops with built-in scales for weighing the ground feed for each cow. Sometimes these little helps save as much time as more expensive equipment like gutter cleaners, silo unloaders, and feed carts.

The over-all objective of the current work on the methods engineering projects is to find the best combinations of building design, arrangements, sanitation, equipment, and operator technique for making the dairy enterprise more successful. Hog raising, beef cattle production, etc., are to be studied with the same approach.

New Federal and State Bulletins

Wiring the Farmstead for Efficiency, by O. J. Trenary, Extension Bulletin 397-A, May 1947, Colorado A. & M. College.

Homemade Fertilizer Applicator, by O. J. Trenary, Extension Circular 147-A, April 1947, Colorado A. & M. College.

Construction Details for Making a Mechanical Post Hole Digger, by H. H. Kob and O. J. Trenary. Extension Circular 144-A, February, 1947, Colorado A. & M. College.

Domestic Spark Arresters, by Henry Giese. Research Bulletin 348, June 1947, Iowa Agricultural Experiment Station.

A G-E FARM WELDER

WILL HELP YOU KEEP MACHINERY *On the job* DURING HARVEST

Repair and modify old equipment...make new machines, too

A complete Farm Welder, including an assortment of electrodes and all necessary accessories

When some metal part on your vital farm machinery wears thin and breaks during harvesting and crop-handling—the draw-bar on your tractor, for instance—what do *you* do?

Perhaps you stop operations, dismantle the machine, take the broken part to town and wait for repairs. But, that's a sure-fire way to waste your time and money.

If you're wise, you'll own a General Electric Farm Welder. Because if you do, it's easy to make on-the-spot, permanent repairs of many broken metal parts by a simple welding job *you*, yourself, can do. You get your machinery back on the job without loss of time, without fuss and bother. Besides, a weld you make with your own Farm Welder costs you much less.

In designing this invaluable tool for the modern farm, G-E engineers tailored it specifically for use on rural power lines. The welder, in construction and in operation, meets the requirements of NEMA and is listed by the Underwriters' Laboratories.

4 MAJOR ADVANTAGES

In its unique design and construction:

- **SIMPLE TO USE**
  A brief period of self-instruction and you're ready to weld.
- **READILY PORTABLE**
  Light-weight and compact in construction, it occupies less than two square feet of floor space—easy to move wherever power is available.
- **SAFER TO OPERATE**
  Complete grounding, use of lowest practical welding voltage and built-in protection against overload assure maximum protection, to user and long life to welder.
- **DURABLE CONSTRUCTION**
  Strong, light-weight steel case encloses a unit with no rotating parts to wear out.

Available in ratings of 130 and 180 amperes and for use wherever ordinary 230 volt a-c current is available, some models are priced as low as $152. See your own General Electric Farm and Home Dealer *today!* He will be glad to give you complete information, including advice on the model you require. *Farm Industry Division, General Electric Co., Schenectady 5, N. Y.*

GENERAL ELECTRIC

669-51

NEWS SECTION

Farm Electrification Conference

THE second National Farm Electrification Conference will be held at the Claypool Hotel, Indianapolis, Indiana, October 7 and 8. Three major addresses and four panel discussions of problems vital to the continued success of farm electrification will feature the program of this conference.

The first session, on the forenoon of October 7, will be opened by Hassil E. Schenck, president, Indiana Farm Bureau, Inc., who is chairman of the Conference. The address of welcome will be made by the Hon. Ralph E. Gates, governor of Indiana. The remainder of the session will be devoted to a panel discussion on distribution and servicing of farm electrical equipment, of which Hugh Curtis, managing editor, Successful Farming magazine, will be chairman.

At the afternoon session the same day, at which Truman E. Hienton, head, USDA Farm Electrification Division, will preside, an address on agricultural development activities by power suppliers will be made by L. M. Smith, vice-president and director of public relations, Alabama Power Co. This will be followed by a panel discussion, with an exhibit demonstration, on farm wiring and rewiring, the chairman of which will be J. R. Waters, rural service manager, Monongahela Power Co. This will be followed by general discussion.

The Conference dinner will be held the evening of October 7, which will be featured by an address by J. E. Stanford, executive secretary, Kentucky Farm Bureau Federation.

Geo. W. Kable, editor, Electricity on the Farm, and vice-chairman of the Conference, will preside at the forenoon session on October 8, the program feature of which will be a panel discussion on farm and home uses of electricity, experimental and research work, and unfilled farm electric equipment needs, the chairman of which will be Geo. A. Rietz, president, American Society of Agricultural Engineers, and manager, farm industry division, General Electric Co. The business meeting of the Conference will conclude this session.

Conference Chairman Schenck will preside at the afternoon session on October 8, which will open with an address by the Hon. Claude R. Wickard, administrator, Rural Electrification Administration, on a new era in agriculture. This address will be followed by a panel discussion on education and in-service training, the chairman of which will be J. H. McLeod, acting director, Tennessee Agricultural Extension Service. This discussion will be followed by short summaries and suggestions by each panel chairman, and Chairman Schenck will close with a summary of the entire conference.

The National Farm Electrification Conference is guided by a steering committee composed of representatives of the following fifteen participating organizations: Agricultural Education Service (U. S. Office of Education), American Agricultural Editors Association, American Farm Bureau Federation, American Institute of Electrical Engineers, American Society of Agricultural Engineers, American Society of Mechanical Engineers, American Washer and Ironer Manufacturers' Association, Canadian Electrical Manufacturers Association, Edison Electric Institute, Farm Equipment Wholesalers Association, National Association of Farm Water Supply Manufacturers, National Electrical Contractors Association, National Electrical Manufacturers Association, National Electrical Retailers Association, and National Electrical Wholesalers Association. All individuals and organizations having an interest in farm electrification are cordially invited to attend the Conference and participate in the program.

A.S.A.E. Meetings Calendar

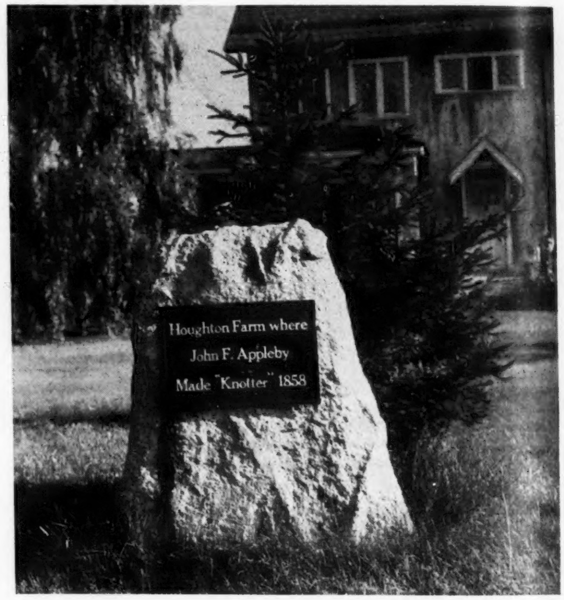
October 12—WASHINGTON (D.C.) SECTION, Room 6962, South Agriculture Bldg., USDA, Washington, D. C.

October 23 and 24—PENNSYLVANIA SECTION, Agricultural Engineering Bldg., Pennsylvania State College, State College, Pa.

October 23 and 24—PACIFIC NORTHWEST SECTION, Davenport Hotel, Spokane, Wash.

December 15 to 18—FALL MEETING, Stevens Hotel, Chicago.

June 20 to 23—ANNUAL MEETING, Multnomah Hotel, Portland, Oregon.



The marker in this picture commemorates the invention in 1858 by John Francis Appleby of the knotter for grain binders. It is located on the farm of a grandson of Appleby — a Mr. Houghton, who at one time was employed by J. I. Case Co. as an engineer on corn pickers. The Houghton farm is in southern Wisconsin about 10 miles east of Whitewater at the junction of state highway No. 12 and county trunk K — on the main highway from Chicago to Minneapolis. Photo is by courtesy of F. N. G. Kranick and D. H. Daubert

This picture shows the new agricultural engineering building on the campus of the State College of Washington at Pullman. It is a two-story, brick and wood structure and has a total floor area of 15,780 square feet

Farm Structures Course

A FOUR-DAY farm structures conference and training course, sponsored jointly by the Farm Structures Division of the American Society of Agricultural Engineers and the College of Agriculture, University of Illinois, will be held on the University campus September 15 to 18. It is the third of a series for representatives of public service and industrial organizations interested in farm structures and housing, and is offered in response to numerous requests.

The objective of the course will be to study current conditions and outlook for farm building improvement, new developments in materials and construction, the results of research, animal shelter and crop storage requirements, farm housing, and educational and promotional methods. Deane G. Carter, professor of farm structures at the University of Illinois, will be in charge of the course, and he will be assisted by Keith Hinchcliff and other staff members of the agricultural engineering department and the Small Homes Council.

Persons interested may make immediate application for enrollment in the course. Hotel accommodations may be arranged direct with local hotels or through the agricultural engineering department. For additional information write D. G. Carter, agricultural engineering department, University of Illinois, Urbana.

Personals of A.S.A.E. Members

Thomas P. Christen, Jr., has resigned his position as design engineer with the Ohio Cultivator Division of the National Farm Machinery Co-operative, to accept a position as agricultural sales engineer for the Standard Oil Co. of Ohio. He will continue to live at Bellevue, Ohio.

Wesley A. Harper recently resigned as agricultural engineer for the Rome Plow Company to accept the position of chief engineer with National Farm Machinery Cooperative, Inc., at Bellevue, Ohio.

Walter E. Matson is now employed as a part-time instructor in rural electrification at the State College of Washington, Pullman, and as an investigator for the Washington Committee on the Relation of Electricity to Agriculture.

William J. Oates has resigned as a member of the agricultural engineering staff of the University of Florida, to accept appointment as professor of agricultural engineering at Oklahoma A. & M. College, Stillwater, effective September 1.

John H. Ploehn, chief engineer, French & Hecht Division, Kelsey-Hayes Wheel Company, Davenport, Iowa, has retired after 34 years of service. Mr. Ploehn joined the French & Hecht organization in 1913 and was for many years plant superintendent. Prior to his association with French & Hecht, he was connected with the Bettendorf Company as superintendent of the steel foundry. He is an engineering graduate of Purdue University.

John A. Price has been advanced from the position of engineer in charge of development for the Midland Company, manufacturers of farm and garden implements, to the position of chief engineer of the company.

Marvin L. Stark recently resigned as field engineer for the Farmer's Mutual Reinsurance Association to accept a position as design and research engineer with the Lenox Furnace Co. at Marshalltown, Iowa.

Homer D. Witzel has been promoted from the position of chief engineer to that of factory manager of the Harris Mfg. Co., Stockton, Calif.

Professional Registration of Agricultural Engineers*

IN a general study of the problem of professional registration of agricultural engineers, the A.S.A.E. Committee on Professional Registration has secured information in the form of literature and personal correspondence from the Engineers Council for Professional Development (E.C.P.D.) and the National Council of State Boards of Engineering Examiners (N.C.S.B.E.E.). The work of the E.C.P.D. is generally known to A.S.A.E. members and will not be reviewed. The N.C.S.B.E.E. is probably not so well known; a statement of its purpose and policy is as follows:

"The N.C.S.B.E.E. is an advisory and coordinating agency established primarily to assist state boards in registration for professional engineers in a more efficient and uniform administration of state registration laws; and its functions and activities include the certification of engineers, jointly with state boards, for reciprocal registration in the various states, and the operation of a national clearinghouse and information bureau for matters pertaining to the legal registration of professional engineers, serving state boards, state committees, engineering societies, individual engineers, and the public."

*From a report of the Committee on Professional Registration, American Society of Agricultural Engineers—S. M. Henderson (chairman) and R. K. Frevert.

Besides its other activities, the N.C.S.B.E.E. in 1929 sponsored the "Model Law for the Registration of Professional Engineers," and, with the cooperation and assistance of the American Society of Civil Engineers, promoted its review and adoption by other national engineering organizations. Many of the state registration laws are based entirely or in part upon this model law. It has been approved and endorsed by the following organizations: American Society of Civil Engineers, American Society of Mechanical Engineers, American Association of Engineers, American Institute of Consulting Engineers, National Society of Professional Engineers, National Council of State Boards of Engineering Examiners, American Institute of Electrical Engineers, American Society of Heating and Ventilating Engineers, American Institute of Mining and Metallurgical Engineers, Illuminating Engineering Society, Society of Naval Architects and Marine Engineers, American Institute of Chemical Engineers, and American Society of Engineering Education.

Although the N.C.S.B.E.E. is officially composed of representatives of state boards of engineering examiners and is financed by dues from these boards, the various engineering societies are represented at its meetings, act in an advisory capacity, and voluntarily provide some financial support.

The A.S.A.E. Committee made a survey of the various state registration boards, the following questions being asked in the questionnaire that was sent: (1) Are your state registration laws based on the "Model Law"? (2) How many agricultural engineers are registered in your state as professional engineers? (3) How many agricultural engineers are registered in your state as land surveyors? (4) How many agricultural engineers are registered in your state as professional engineers and land surveyors?

Forty states cooperated in the survey by returning the questionnaires. From these it was learned that 55 agricultural enginers were reported registered in the agricultural engineering branch of engineering as professional engineers in the 40 states. On this basis, it can be estimated that there are 66 agricultural engineers registered in this country, or about 3 per cent of our profession. Thirty-nine per cent of all engineers in the United States are registered.

The results from the questionnaire also showed that approximately two-thirds of the state registration laws are based on the Model Law. Others are similar. According to the Model Law a graduate from an E.C.P.D. accredited school with requisite experience may be registered without examination. Irrespective of education, registration may be secured by passing a written examination. This means that an agricultural engineer is a potential registrant in any state in which agricultural engineering is recognized as a branch of professional engineering, even if he is not a graduate in an accredited curriculum.

Twelve out of 20 states reporting the foregoing information do not recognize agricultural engineering as a distinct branch of engineering. However, some states do not specify the branch of engineering when registering, so the 12 to 20 ratio may not be a fair sample.

Although accrediting is recognized as highly desirable, it does not seem generally necessary to insure recognition of agricultural engineering as a branch of engineering by the state registration boards.

The A.S.A.E. Committee recommends that the Society be represented at the next N.C.S.B.E.E. annual meeting in October, to which it has been formally invited, in order to further the recognition of agricultural engineering by state boards and secure information helpful in the Society's registration activity; also that a formal attempt be made to evaluate the need and desirability of registration, the results of which should be brought to the attention of Society members. It is generally known that registration is becoming more advisable as time goes on. This trend should be carefully studied from the standpoint of the agricultural enginer.

Washington Section Invites

THE Washington (D.C.) Section of the American Society of Agricultural Engineers extends a cordial invitation to all A.S.A.E. members and friends to attend any of its luncheon meetings (11:50 a.m.), usually held the second Friday of each month, September to June inclusive, in Room 6962 South Agriculture Building, USDA, Washington. A tentative schedule of meetings has been announced for the ensuing year.

The meeting on October 10 will be devoted to the subject of flood control, and the one on November 14 to the relation of agricultural engineering to agriculture. At the December meeting on Thursday, December 11, it is hoped to have the Secretary of Agriculture as the principal speaker. The January 9 meeting will be devoted to the subject of farm equipment. The meeting for February 13 will be held in the evenings, and is designated as "ladies' night", the program of which will be on housing equipment and nutrition. The meeting on March 12 will feature the work of the agricultural engineer at a state college. The national president and secretary of the Society are the scheduled speakers for the meeting on April 9. At the May 14 meeting it is hoped to have as the principal speaker, J. Dewey Long, who will then have completed a year of duty as agricultural engineering consultant to the Republic of Colombia. The final meeting of the year, on June 11, will consist of a tour of the USDA research center at Beltsville, Md.

Necrology

WALTER L. CHURCHMAN, general manager of Andelot, Inc., was fatally injured July 18, in an airplane crash near Marshallton, Del.

He was born April 27, 1910, in Newark, Del., and received his B.S. degree in agriculture from the University of Delaware in 1932. From 1934 to 1937 he held a fellowship at the University, studying the effects of copper sulfate on cotton and flue-cured tobacco. From 1937 to 1939 he was assistant agricultural chemist for the Delaware State Board of Agriculture.

He became associated with Andelot, Inc., in 1939 as assistant general manager, and was promoted to general manager in 1941. He had been elected to membership in A.S.A.E. in September, 1946.

GILLIS C. KELLAHER, secretary, Multnomah Iron Works Division, R. M. Wade and Co., Portland, Oregon, passed away June 9. He was born February 24, 1894, at Cambridge, Mass., and completed his technical training at the U. S. Naval School at Norfolk, Va. He resigned a naval commission as ensign in December, 1918; became associated with the Wade organization shortly thereafter, and continued with it until his passing. His work included design and supervision of design of a variety of farm equipment. He was elected to membership in the A.S.A.E. in 1940.

MILTON L. STANIUS, farm equipment test and development engineer, Sears, Roebuck and Co., passed away August 7, 1947, of injuries received in an automobile accident.

He was a mechanical engineer who entered agricultural engineering work in 1929 through employment in the International Harvester Co., as a designer working on tractors and cotton harvesting machinery. He became associated with Sears, Roebuck and Co. in 1943, and was elected to membership in A.S.A.E. in 1944. He is survived by his widow.

G. E. WENZLOFF, general manager, Zellwood Drainage and Water Control District, Zellwood, Fla., is reported to have passed away recently. He was born November 5, 1904, at Emden, N. D. After two short terms at North Dakota Agricultural College, and additional study at Dunwoody Institute, he gained experience in welding, blacksmith, and boiler work; and followed this into work in rebuilding, installing, and operating dredging equipment. In 1924 he became superintendent of the Gladeview Drainage District in Florida, and from 1927 to 1931 served as chairman of its board of supervisors. From 1931 to 1933 he was superintendent of the 25,000-acre Texas wheat farm operated by Hickman Price. Then after three years in the grain, feed, and seed business he joined the engineering department of the U. S. Sugar Corporation of Clewiston, Florida. In 1934 he became a member of A.S.A.E. He is survived by his widow.

AUGUSTUS F. WHITFIELD, president, Clover Fork Coal Co., Kitts, Ky., passed away February 18, 1947, according to word only recently received. He was 85 years of age and had been a member of A.S.A.E. for the past 20 years. He was actively concerned with drainage and other improvements for agricultural use of land in the vicinity of coal mines.

"It Can't Happen Here"

(Continued from page 385)

processing. During this period of change the population increased 45 per cent, but production of truck crops went up 242 per cent, fruits and nuts 113 per cent, and dairy and poultry products, 62 per cent.

Mechanical innovations which provided simple, economical means for processing and packaging foodstuffs have added to the variety on grocery shelves and enabled us to store surplus foods for use when needed. Since the beginning of this century the output of the food manufacturing industry has increased four-fold and nearly three-fourths of the money spent for food buys their products. Important advances in processing are being made constantly. It was only a few years ago that manufacturers began putting tomato juice in cans and bottles. Within a decade consumption had quadrupled and the product had a place on every pantry shelf.

As technological progress has brought once-rare foods into our every day eating, its latest advances have made possible new luxuries for the dinner tables of those who can afford them. . . .

Thus, we are blessed not only with a freedom from fear of hunger, but with the assurance of a good supply of widely varied foods . . . because we live in a land that produces 95 per cent of the food we consume and whose industrial development insures efficient distribution and safe processing for storage.

Famine? — it can't happen here.

L. J. FLETCHER.

Director of training and community relations,
Caterpillar Tractor Co.

Why 8 out of 10 tractor owners prefer gasoline

Ask tractor owners what fuel they prefer, and 8 out of 10 will tell you they prefer gasoline. Their chief reasons for this choice are the convenience, economy and flexibility—and, of course, the extra power that gasoline gives when the going is tough.

Gasoline gives more power than any other fuel—particularly when used in a modern, high compression tractor. Extra power means plenty to a farmer when plowing, doing other heavy jobs, or racing to beat the weather and make crops on schedule.

All tractor manufacturers are making high compression gasoline tractors today. Here's one of the newest—the 1,200 lb. Farmall Cub. Its compact, highly efficient high compression engine makes possible a lot of power in a small package, is easy on gasoline.

When you recommend a high compression gasoline tractor to a farmer, you are helping him to get what he wants—more power, convenience and all-round economy—a tractor that will serve him well, tomorrow as well as today. *Ethyl Corporation.*

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

William S. Allen, extension agricultural engineer, A. & M. College of Texas, College Station, Tex. (Mail) Box 2337

Charles E. Ball, research fellow in agricultural engineering, Iowa State College, Ames, Iowa.

C. Howard Bingham, extension agricultural engineer, Pennsylvania State College, State College, Pa.

William Black, assistant manager, flame cultivation division, New Holland Machine Co., New Holland, Pa.

Berthoud C. Boulton, head of experimental engineering, Deere & Co., Ankeny, Iowa.

William B. P. Brown, manager of manufacturing, International Harvester Company of Australia Pty., Ltd., North Shore, Geelong, Victoria, Australia.

William A. Calvert, Jr., farm representative, Pennsylvania Power & Light Co. (Mail) 40 Parker St., Carlisle, Pa.

Howard A. Downey, sales representative, New Holland Machine Co., New Holland, Pa. (Mail) 315 E. Main St.

A. L. Draegert, agricultural sales engineer, Public Service Co. of Northern Illinois. (Mail) 1701 So. 1st Ave., Maywood, Ill.

C. Geyari-Lowenthal, manager of technical office, Meshek Ein, Harod, Palestine.

Lyle E. Kittilsby, special representative, tillage and seeding machinery, International Harvester Co. (Mail) 125½ 6th St., S. E., Minot, N. D.

William H. Knight, rural electrification investigator, Idaho C.R.E.A., University of Idaho. (Mail) 509 South St., Pullman, Wash.

McNeal Marshall, assistant extension agricultural engineer, Virginia Polytechnic Institute, Blacksburg, Va.

Joe T. Rogers, student in agricultural engineering, A. & M. College of Texas. (Mail) Box 67, Lone Oak, Tex.

Joe K. Shiver, student trainee, J. I. Case Co. (Mail) 70 14th St., Atlanta, Ga.

S. H. Strathman, secretary-manager, California Farm Equipment Dealers Assn., 415 Chapman Bldg., Fullerton, Calif.

Ray C. Tegtmeyer, chief engineer, Marathon Foundry & Machine Co., Wausau, Wis.

L. Rohe Walter, director of public relations, The Flintkote Co., 30 Rockefeller Plaza, New York 20, N. Y.

Lewis A. West, manufacturers' representative, Papec Machine Co. (Mail) R. R., Branchville, N. J.

W. T. Wheeler, southwest district representative, tillage and seeding machine and beet-harvesting equipment, International Harvester Co. (Mail) 2201 Northwest 30th St., Oklahoma City, Okla.

TRANSFER OF GRADE

Francis X. Olney, instructor in gunnery, U. S. Army. (Mail) c/o W. L. Koch, Triplett, Mo. (Junior Member to Member)

George E. Webster, principal, State School of Agriculture, Randolph Center, Vt. (Associate to Member)

New Federal and State Bulletins

Principles of Burley Tobacco Barn Operation, by Lester S. O'Bannon, published as Kentucky Agricultural Experiment Station Bulletin 501 (May, 1947). Heating and ventilating recommendations specifically applicable to Burley tobacco curing, and of general interest in connection with the curing of other farm crops.

Tobacco Stripping Lights, by Earl G. Welch, University of Kentucky Agricultural Extension Leaflet 111 (June, 1947). Types and suggestions for installation.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN: 1946 JUNE—O-506. SEPTEMBER—O-516. NOVEMBER—O-523. DECEMBER—O-526. 1947 MARCH—O-543. APRIL—552, 555, 556, 557. MAY—O-559, 560, 564. JUNE—O-567, 568, 569, 570, 571, 572, 573. JULY—O-574. AUGUST—O-576, 577, 579, 580.

POSITIONS WANTED: 1946 FEBRUARY—W-207. APRIL—W-237. MAY—W-309. JUNE—W-320. SEPTEMBER—W-337. 1947 FEBRUARY—W-373. APRIL—W-386, 387, 389. MAY—W-392, 394, 395, 397, 398, 100, 101, 103. JUNE—W-104, 105, 106. JULY—W-109, 111, 112. AUGUST—W-114, 116, 117, 118.

NEW POSITIONS OPEN

DESIGN ENGINEER EXECUTIVE to take complete charge of future design and development of portable heating device now in production. Mechanical engineering education or equivalent. Location Midwest. At least 5 years in charge of design and development of medium weight equipment with previous similar experience in lesser capacity. Ability to make sound engineering and other decisions. Manufacture of product is increasing and will become a major part of the employer's business. Age 35-45. Salary, $6000 range. O-581

AGRICULTURAL ENGINEER (instructor) for teaching in farm shop and power machinery, and for research in farm structures and hay curing, in eastern land grant college. BS deg in agricultural, civil, or mechanical engineering. Farm background. Previous teaching or research experience desirable. Good health, orderly thinking and work habits, and ability to meet and work with college students and farm people. Annual basis, with one month vacation. If successful applicant does not have MS deg, arrangements can be made for graduate study. Salary $2640. O-582

RESEARCH AGRICULTURAL ENGINEER for work on mechanical potato harvesting project in state agricultural experiment station in Northwest. BS deg in agricultural engineering, or equivalent. MS deg desirable. Prefer man with experience in research work and agricultural machine design. Must be able to cooperate with farmers. Policies governing regular employees govern advancement. Age, 25-40. Salary, up to $4,500. O-583

SALES ENGINEERS to contact retail dealers in nationally-known line of garden tractors and attachments. Manufacturer located in Midwest. Several territories open. Agricultural engineering training and practical experience in field of garden tractors or power mower equipment. Usual personal qualifications for sales engineering. Extensive traveling. Salary and expenses, with bonus arrangement later. Salary, open. O-584

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER desires design, development, sales, or service work in farm structures field, in private company, extension service, or as project engineer in government agency. Two years college, 7 years construction engineering in government service, 12 years as manager of retail lumber yard. No physical defects. Available 15 days notice. Married. Age 41. Salary $4500. W-119

CIVIL ENGINEER desires work in structures or soil and water field. BS deg in civil engineering, 1925, Georgia School of Technology. Experience in land surveying, 1 vr; as building contractor, 2 yrs; directing agricultural building and maintenance, 10 yrs; land reclamation 2 yrs; land and tax managerial work, 3 yrs; reforestation, 2 yrs; and structural design, 1 yr. No physical defects. Available on 60 days notice. Married. Age, 45. Salary, $5400. W-120

AGRICULTURAL ENGINEER desires development, research or sales work in farm structures field. BS deg in agricultural engineering, September 1947, University of Wisconsin. Research and student assistant in Dairy Barn Research Project, University of Wisconsin, 27 months; engineering chief, dive bomber squadron, U. S. Marine Corps, 2 yrs. No physical defects. Available Oct. 15. Married. Age, 25. Salary open. W-121